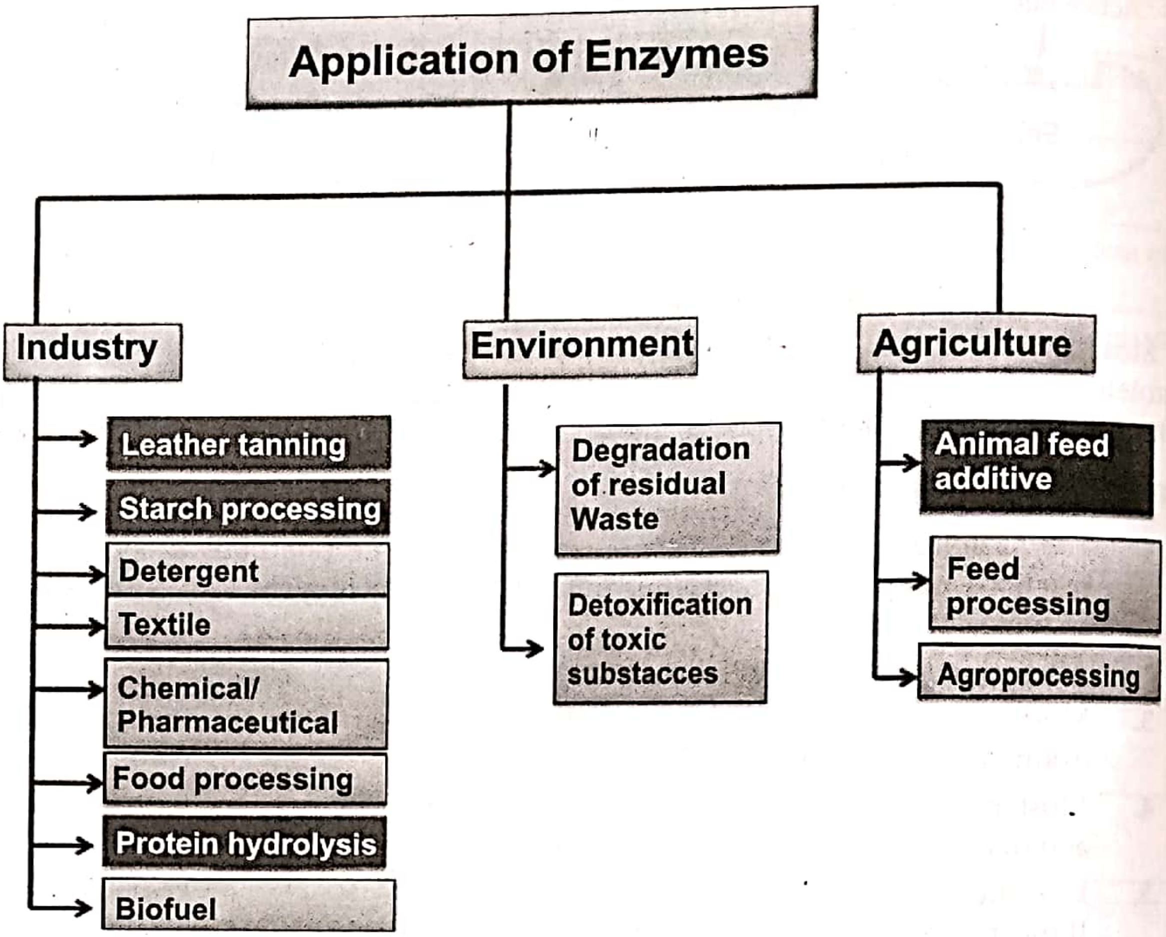
in clarifying fruit juices. *Dairy Industry* - Renin is used in manufacture of cheese. Lipases are used in ripening blue-mold cheese. Lactases breaks down lactose to glucose and galactose.*Meat Tenderizes* - Papain is used to soften meat. *Starch Industry* - Amylases, amyloglucosidases and glycoamylases converts starch into glucose and syrups.



Paper industry - Enzymes like amylases, xylanases, cellulases and liginases lower the viscosity, and removes lignin to soften paper.

Biofuel Industry - Enzymes like cellulases are used in breakdown of cellulose into sugars which can be fermented.

Biological detergent - Proteases, amylases, lipases and cellulases assist in removal of protein stains, oily stains and acts as fabric conditioners.

Rubber Industry - Catalase enzyme converts latex into foam rubber.

Molecular Biology - Restriction enzymes, DNA ligase and polymerases are used in genetic engineering, pharmacology, agriculture, medicine, Polymerised Chain Reaction (PCR) techniques, and are also important in forensic science.

Environment - Enzymes are powerful tools that help sustain a clean environment in several ways. They are utilized for environmental purposes in a number of industries including agro-food, oil, animal feed, detergent, pulp and paper, textile, leather, petroleum, and specialty chemical and biochemical industry. Enzymes also help to maintain an unpolluted environment through their use in waste management.

NUTRIENT BIOAVAILABILITY

Bioavailability is the technical term used to convey the fact that human body does not absorb 100% of all nutrients consumed no matter if one takes them in the form of nutritional supplements or as food. In other words, bioavailability is the degree to which food nutrients are available for absorption and utilization in the body.

It is a critical issue for many nutritional concerns. The absorption of nutrients involves at least three steps: any food must first be digested, then assimilated, and, finally, utilized. Increasing bioavailability may require the manipulation of one or more of these factors. The process of uptake from the digestive system varies greatly from nutrient to nutrient. Vitamin C is absorbed almost exclusively in the small intestine and requires the presence of transport proteins. For vitamin C, these transport proteins are called sodium-dependent vitamin C co-transporters (SVCTs). A lack of these proteins produces a corresponding lack of vitamin C uptake.

Importance of Bioavailability

The role of bioavailability is important in establishing nutrient requirements and using those requirements in food labelling. Nutrient availability is also important in testing and marketing infant foods, nutritional supplements, and enteral formulas. Enteral nutrition, also known as tube feeding, is a way of delivering nutrition directly to your stomach or small intestine. Your doctor might recommend tube feeding if you can't eat enough to get the nutrients you need. An understanding of bioavailability is also important because consumers continually change their dietary patterns for reasons of health, economics, or personal preference, and knowledge of nutrient bioavailability may influence their choices.

Factors Affecting Nutrient Bioavailability

Many factors influence a nutrient's bioavailability, including the food's digestibility and the nutrient's absorbability from the intestinal tract, which are affected by nutrient binding to indigestible constituents and nutrient-nutrient interactions in food raw materials. Processing and cooking procedures also can influence nutrient bioavailability. Apart from the food itself, different animal species exhibit variations in bioavailability of specific nutrients from a particular food. The age, sex, physiological health, consumption of drugs, general nutritional status, combinations of foods eaten together, and other factors all influence the ability of an individual to make use of a particular nutrient.

How to increase nutrient bioavailability

Many factors can interfere with or boost nutrient bioavailability at every step along the way. More than 90% of the carbohydrates, proteins and fats are absorbed and used, while the bioavailability of vitamins, minerals and phytochemicals varies.

Optimize your gastrointestinal system for better nutrient absorption: The heart of nutrient absorption lies within gastrointestinal system and proper digestion. If you optimize digestion and remove things that may be inhibiting absorption within this system, you'll reap more of the benefits of the foods and juices you consume.

De-Stress: Digestion occurs better in a relaxed, stress-free environment.

Add spice. An ingredient in pepper, called piperine, has been shown to increase the bioavailability of nutrients by up to 2000%.

Chew It Up! To extract nutrients efficiently, the body must break down food efficiently. The first line of breakdown happens with chewing. While most of us chew enough to swallow, consciously chewing longer can optimize absorption as it creates less work for the GI system.

Stock up on healthy bacteria. Probiotics — living microorganisms called "healthy bacteria" — help defend the body against "bad bacteria. **Probiotics**, or live bacteria, from fermented dairy products such as yogurt may improve the bioavailability of calcium.

Add oil to Foods: Oil improve the bioavailability of fat-soluble nutrients such as carotenoids and vitamins A, D, E and K.

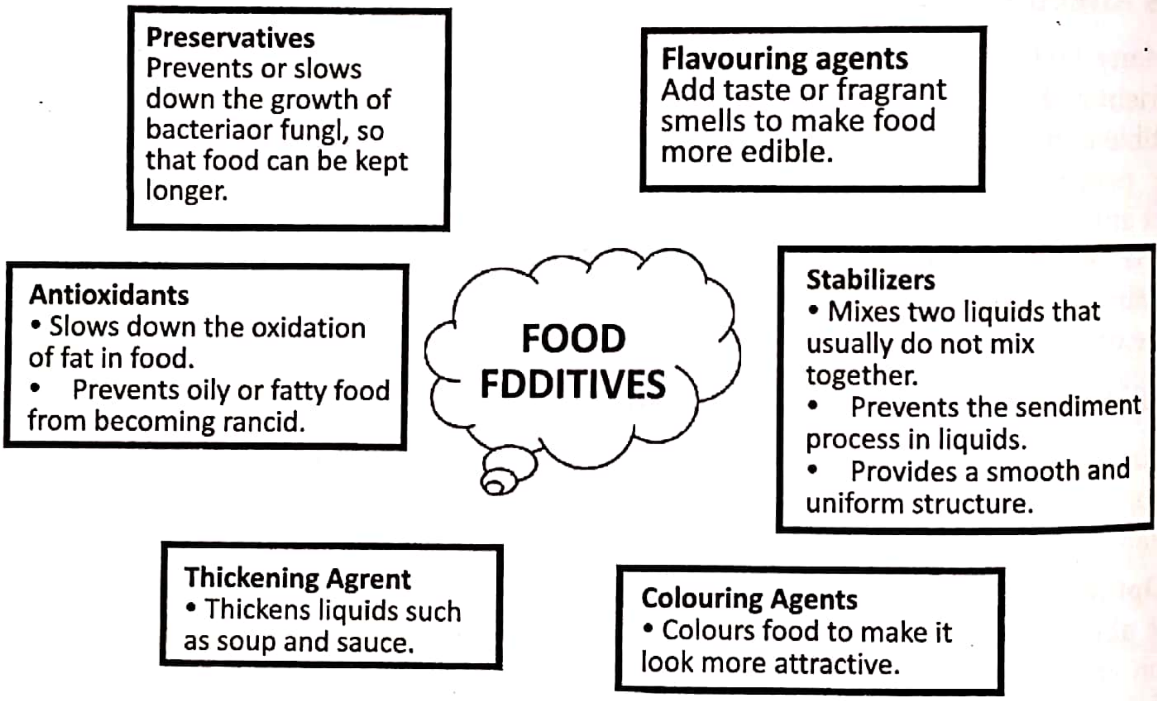
Nutrients Boost Absorption: A few nutrients improve the bioavailability of other nutrients. One well-known example is vitamin D, which human body needs to absorb calcium.

FOOD ADDITIVES

Food additives are substances that are intentionally added to food or animal feed during processing or storage. They include antioxidants, preservatives, colouring and flavouring agents, emulsifiers, stabilizers, sweeteners and anti-infective agents. Most food additives have little or no nutritional value. Since ancient times table salt has been a preservative for fish, meat, and beef, and sugar has been used to preserve jelly, fruit jams, and fruit preserves. At present more than 2500 food additives of all kinds are known.

Types of Food Additives

Below is a rough categorisation of additive types. Some additives belong to more than one category. For example, sugar is both a preservative and a sweetener.



Preservatives
Prevents or slows down the growth of bacteriaor fungl, so that food can be kept longer.

Flavouring agents
Add taste or fragrant smells to make food more edible.

Antioxidants

- Slows down the oxidation of fat in food.
- Prevents oily or fatty food from becoming rancid.

Stabilizers

- Mixes two liquids that usually do not mix together.
- Prevents the sendiment process in liquids.
- Provides a smooth and uniform structure.

Thickening Agent

- Thickens liquids such as soup and sauce.

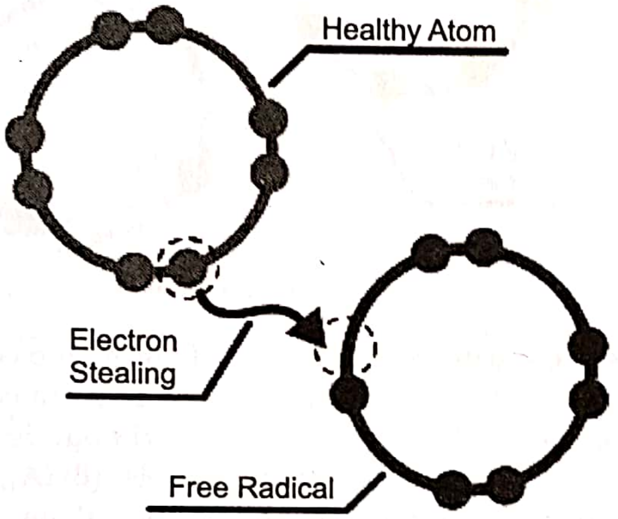
Colouring Agents

- Colours food to make it look more attractive.

In the European Union (EU) all food additives are identified by an *E number*, while "E" stands for Europe. Food additives are always included in the ingredient lists of foods in which they are used. Product labels must identify both the function of the additive in the finished food (e.g. colour, preservative) and the specific substance used either by referring to the appropriate E number or its name e.g. E101, vitamin B2 (Riboflavin).

ANTIOXIDANTS

The cells in human body contain both positive and negative charges. The cell is neutral, i.e. its charges are equally paired. However, when the cells are exposed to oxygen, they break down through a process known as oxidation. A substance is oxidized if it gains oxygen, loses hydrogen, or loses electrons. The charged particles are now left without pairs, i.e. they are free. This is why these cells are known as free radicals.



FREE RADICALS AT WORK

The problem arises when these free radicals try to achieve their old state of stability by converting other stable cells to free radicals. This kicks off a chain reaction that has the power to cause oxidative stress. Oxidative stress has been linked to critical diseases.

Some conditions caused by free radicals include:

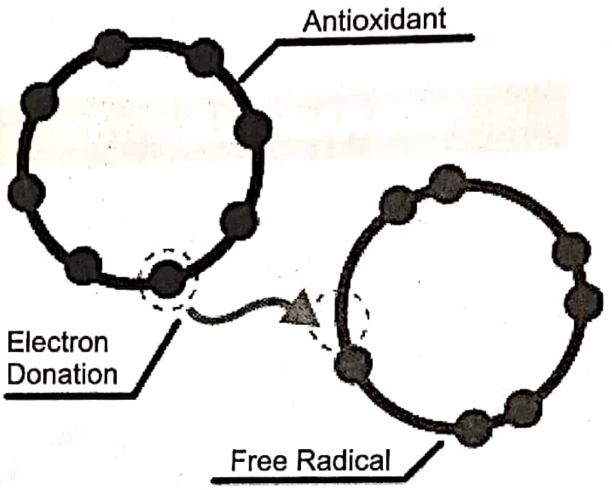
1. Deterioration of the eye lens, which contributes to blindness.
2. Inflammation of the joints (arthritis).
3. Damage to nerve cells in the brain, which contributes to conditions such as parkinson's or alzheimer's disease.
4. Acceleration of the ageing process.
5. Increased risk of coronary heart disease, since free radicals encourage low-density lipoprotein (LDL) cholesterol to stick to artery walls.
6. Certain cancers, triggered by damaged cell DNA.

Free radicals are also produced from exposure to cigarette smoke, excess exposure to the sun, drinking alcohol, from exposure to large amounts of heavy metals and during any inflammatory response. Body has antioxidants to fight these free radicals. These antioxidants include vitamin E, Vitamin C, Zinc Iron, vitamin A, Beta carotene and Selenium.

How Do Antioxidants Work?

Antioxidant compounds are one of the chief defence mechanisms used by the body to prevent free radical formation. They prevent or slow down cell damage by donating electron to these free radicals, in effect neutralizing the harmful chain reaction that free radicals can set off.

ANTIOXIDANTS AT WORK



These substances are used to prevent oxidation of fats by molecular oxygen. Without them, potato chips, breakfast cereals, salted nuts, fat-containing dehydrated foods, crackers, and many other fat-containing foods could not be stored very long without developing rancidity. Principal among these antioxidants are butylated hydroxy anisole (BHA), butylated hydroxytoluene (BHT), tertiary butylated hydroquinone (TBQH), and propyl gallate.

The best way to stay healthy is to eat a wide variety of vitamin-rich foods. They're packed with vitamins, minerals, and antioxidants, which minimize the cell damage. Foods rich in antioxidants are grapes, blueberries, red berries, nuts, dark green vegetables, tea, etc.

FOOD PROCESSING AND PRESERVATION

Food preservation is any of a number of methods by which food is kept from spoilage after harvest or slaughter. Among the oldest methods of preservation are drying, refrigeration, and fermentation. Modern methods include canning, pasteurisation, freezing, irradiation, and the addition of chemicals. Advances in packaging materials have played an important role in modern food preservation.

Major Causes of Food Deterioration

The major factors affecting food deterioration include the following:

(1) growth and activities of microorganisms, principally bacteria, yeasts, and molds;
(2) activities of food enzymes and other chemical reactions within food itself;
(3) infestation by insects, parasites, and rodents;
(4) inappropriate temperatures for a given food;
(5) either the gain or loss of moisture;

(6) reaction with oxygen;
(7) light;
(8) physical stress or abuse; and
(9) time.

These factors can be divided into **biological, chemical,** and **physical** factors.

Principles of food Preservation

Effective preservation must eliminate or minimize all of these factors in a given food. Principles of Food preservation are largely directed at inactivating or controlling microorganisms, enzymes, and reducing or eliminating chemical reactions which cause food spoilage. The most important means of preserving foods are heat, cold, drying, acid, sugar, salt, smoke, air, chemicals, and radiation.

Heat

Most bacteria, yeasts, and molds grow best in the temperature range of about 16 to 38°C. Thermophiles will grow in the range 66-82°C. Most bacteria are killed in the range 82-93°C, but many bacterial spores are not destroyed even by boiling water at 100°C for 30 min. To ensure sterility, that is, total destruction of microorganisms including spores, a temperature of 121°C (wet heat) must be maintained for 15 min or longer. This is generally done with steam under pressure, as in a laboratory autoclave.

It is not always necessary to kill all microorganisms and produce a sterile product. It may be necessary to employ only sufficient heat to destroy disease-producing organisms in the food. This is done in the case of pasteurized milk. Most of the bacteria and all of the disease-producing organisms that might be present in milk are destroyed by pasteurization at 63°C for 30 min, but the milk is not sterile. Nor need it be, since it will be held in a refrigerator and consumed generally within a few days.

Cold

Most bacteria, yeasts, and molds grow best in the temperature range 16--38°C. Psychrotrophs will grow down to 0°C, the freezing point of water, and below. At temperatures below 10ºC, however, growth is slow and becomes slower the colder it gets. When the water in food is completely frozen, there is no multiplication of microorganisms. But in some foods all of the water is not frozen until a temperature of -10ºC or lower is reached. This is because of dissolved sugars, salts, and other constituents, which depress the freezing point. The slowing of microbial activity with decreased temperatures is the principal behind refrigeration and freezing preservation.

Drying

Microorganisms in a healthy growing state may contain in excess of 80% water. They get this water from the food in which they grow. If the water is removed from the food, water will also be removed from the bacterial cells and multiplication will stop. Drying is used as a food preservation technique since ages.

Acid

In sufficient strength acid modifies bacterial proteins as it denatures food proteins and so microorganisms are sensitive to acid. Some are much more sensitive than others, and the acid produced by one organism during fermentation often will inhibit another type of organism. This is one of the principles of controlled fermentation as a means of preserving foods against growth of proteolytic and other types of spoilage organisms. Acid may be produced in foods by adding acid-producing bacterial cultures, or acids may be added directly to foods; examples are citric acid and phosphoric acid added to soft drinks.

Sugar and Salt

Fruits are preserved by placing them in a sugar syrup, and certain meat products are preserved by placing them in a salt brine. Active microorganisms may contain in excess of 80% water. When bacteria, yeasts, or molds are placed in a heavy sugar syrup or salt brine, water in the cells moves out through the membrane and into the concentrated syrup or brine. Water moves from the cell containing 80% water into the syrup or brine, which may contain only 30% or 40% water. The tendency to equalize water concentration inside and outside the cell in this case causes a partial dehydration of the cell, referred to as plasmolysis, which interferes with microorganism multiplication.

Smoke

As with most preservative methods, smoke was used long before the reasons for its effectiveness were understood. In preserving foods such as meats and fish with smoke, the preservative action generally comes from a combination of factors. Smoke contains preservative chemicals such as small amounts of formaldehyde and other materials from the burning of wood. In addition, smoke generally is associated with heat which helps kill microorganisms. This heat also tends to dry out the food, which further contributes to preservation.

Atmosphere Composition

To control organisms that require oxygen, air is removed oxygen for organisms that cannot tolerate it, air is provided. It is often fairly easy to exclude air from aerobes such as molds. Wax coating of cheeses or oxygen impermeable skin-tight plastic films can be quite effective.

Chemicals

Many chemicals will kill or inhibit the growth of microorganisms, but most of these are not permitted in foods. A few that are permitted, in prescribed low levels in certain foods, include **sodium benzoate, sorbic acid, sodium and calcium propionate, ethyl formate**, and **sulfur dioxide**. These chemicals can inhibit the growth of specific microorganisms. For example, sorbic acid is effective at inhibiting the growth of many molds. Thus, the surface of cheese may be treated with sorbic acid or cottage cheese may have sorbic acid mixed directly in the product. Other Examples include sodium benzoate used in soft drinks and acidic foods, sodium and calcium propionate used in breads and cakes as a mold inhibitor. Substances such as sulfur dioxide, that control browning of fruits and vegetables caused by enzymes, also are considered preservatives.

Radiation

Microorganisms are inactivated to various degrees by different kinds of radiation. X-Rays, microwaves, ultraviolet light, and ionizing radiations are each a type of electromagnetic radiation, differing in wavelength and energy, that have been used to preserve food. These radiations can inactivate enzymes responsible for initiating vegetable sprouting or can kill human disease-causing bacteria and insects.

QUALITY OF PACKED AND FROZEN FOODS

Food stored constantly at 0 °F will always be safe. Only the quality suffers with lengthy freezer storage. Freezing keeps food safe by slowing the movement of molecules, causing microbes to enter a dormant stage. Freezing preserves food for extended periods because it prevents the growth of microorganisms that cause both food spoilage and foodborne illness.

Freshness & Quality: Freshness and quality at the time of freezing affect the condition of frozen foods. If frozen at peak quality, thawed foods emerge tasting better than foods frozen near the end of their useful life. Store all foods at 0° F or lower to retain vitamin content, colour, flavour and texture.

Nutrient Retention: The freezing process itself does not destroy nutrients. In meat and poultry products, there is little change in nutrient value during freezer storage.

Colour Changes: Colour changes can occur in frozen foods. The bright red colour of meat as purchased usually turns dark or pale brown depending on its variety. This may be due to lack of oxygen, freezer burn or abnormally long storage.

How to stop undesirable changes in frozen foods

To avoid any kind of undesirable changes in frozen foods following points must be kept in mind.

Freeze Rapidly: Freeze food as fast as possible to maintain its quality. Rapid freezing prevents undesirable large ice crystals from forming throughout the product because the molecules don't have time to form into the characteristic six-sided snowflake. Slow freezing creates large, disruptive ice crystals. During thawing, they damage the cells and dissolve emulsions. This causes meat to "drip" and lose juiciness. Emulsions such as mayonnaise or cream will separate and appear curdled.

Freezer - Refrigerator Temperatures: If a refrigerator freezing compartment can't maintain zero degrees or if the door is opened frequently, use it for short-term food storage. Eat those foods as soon as possible for best quality. Use a free-standing freezer set at 0 °F or below for long-term storage of frozen foods.

Safe Thawing: Never thaw foods in an unhygienic place such as garage, basement, car, dishwasher or plastic garbage bag; out on the kitchen counter, outdoors or on the porch. These methods can leave your foods unsafe to eat. There are three safe ways to thaw food: in the refrigerator, in cold water, or in the microwave. It's best to plan ahead for slow, safe thawing in the refrigerator. Small items may defrost overnight; most foods require a day or two.

Refreezing: Once food is thawed in the refrigerator, it is safe to refreeze it without cooking, although there may be a loss of quality due to the moisture lost through thawing. After cooking raw foods which were previously frozen, it is safe to freeze the cooked foods. If previously cooked foods are thawed in the refrigerator, you may refreeze the unused portion. Freeze leftovers within 3-4 days. Do not refreeze any foods left outside the refrigerator longer than 2 hours; 1 hour in temperatures above 90 °F.

FOOD PACKAGING

Packaging is an essential medium for preserving food quality, minimising food wastage and reducing preservatives used in food. The packaging serves the important function of containing the food, protecting against chemical and physical damage whilst providing information essential to consumers and marketers.

Whether it's a can, bottle, jar, bag or carton, packaging helps to protect food from contamination such as micro-organisms, pests and other contaminants. Packaging also helps to protect the form, shape and texture of the food inside, preventing the loss of flavours and odours and will often extend the products shelf life. Packaging also assists in regulating the water or moisture content of the food to keep it as fresh as possible. The choice of packaging material should not affect the nutritional quality of a product. Packaging also provides an important medium whereby manufacturers can provide information on product features, nutritional contents and ingredient information. Packaging is a system for preserving the safety and quality of food products throughout the whole distribution chain to consumer by:

- Maximising shelf life.
- Carrying important information on the label relating to preparation, safety and nutrition.
- Providing evidence that the package is intact and the product has not been tampered with.
- Identifying the date and the location of manufacture for inventory control and identification of potential hazards.

EVALUATION OF FOOD QUALITY

Food quality is the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (size, shape, colour, gloss, and consistency), texture, and flavour; and internal factors (chemical, physical, microbial).

Food quality is an important food manufacturing requirement, because food consumers are susceptible to any form of contamination that may occur during the manufacturing process. Many consumers also rely on manufacturing and processing standards, particularly to know what ingredients are present, due to dietary, nutritional requirements (kosher, halal, vegetarian), or medical conditions (e.g., diabetes, or allergies).

Besides ingredient quality, there are also sanitation requirements. It is important to ensure that the food processing environment is as clean as possible in order to produce the safest possible food for the consumer. Food quality also deals with product traceability, (e.g., of ingredient, and packaging suppliers). It also deals with labelling issues to ensure there is correct ingredient and nutritional information.

Reasons for Analyzing Foods

The various purposes that foods are analyzed are briefly discussed below.

1. Government regulations and recommendations.
2. Government agencies have specified a number of voluntary and mandatory standards concerning the composition, quality, inspection, and labelling of specific food products.
3. Nutritional labels state the total calorific value of the food, as well as total fat, saturated fat, cholesterol, sodium, carbohydrate, dietary fibre, sugars, protein, vitamins, calcium and iron.

4. The price of certain foods is dictated by the quality of the ingredients that they contain.
5. One of the most important reasons for analyzing foods from both the consumers and the manufacturer's standpoint is to ensure that they are safe.
6. Food manufacturers need analytical techniques to analyze food materials before, during and after the manufacturing process to ensure that the final product meets the desired standards.
7. Many scientists working in universities, government research laboratories and large food companies carry out *basic research*.

FOOD ADULTERATION

Food adulteration is an act of intentionally debasing the quality of food offered for sale either by the admixture or substitution of inferior substances or by the removal of some valuable ingredient.

Types of Adulteration/Adulterants

Poisonous or Deleterious Substances: Generally, if a food contains a poisonous or deleterious substance that may render it injurious to health, it is adulterated.

Filth and Foreign Matter: Filth and extraneous material include any objectionable substances in foods, such as foreign matter (for example, glass, metal, plastic, wood, stones, sand, cigarette butts), undesirable parts of the raw plant material (such as stems, pits in pitted olives, pieces of shell in canned oysters), and filth (namely mold, rot, insect and rodent parts, excreta, decomposition).

Economic Adulteration: A food is adulterated if it omits a valuable constituent or substitutes another substance, in whole or in part, for a valuable constituent (for instance, olive oil diluted with tea tree oil); conceals or damage in any manner (such as fresh fruit with food colouring on its surface to conceal defects); or any substance has been added to it or packed with it to increase its bulk or weight, reduce its quality or strength, or make it appear bigger or of greater value than it is (for example, meat to which water has been added to make it heavier).

Microbiological Contamination and Adulteration: Generally, the presence of pathogens will render the food adulterated. For example, the presence of Salmonella on fresh fruits or vegetables or in ready-to-eat meat or poultry products will render those products adulterated.

Intentional Contamination: Addition of sand, marble chips, stones, mud, other filth, talc, chalk powder, water and mineral oil

Incidental Contamination: Presence of pesticide residues, tin from can, droppings of rodents and larvae in foods.

Why is food adulterated?

1. When the demand is more than the supply in the market.
2. To come at par with the market competitors by lowering the cost of production.
3. The greed for increased profit margins.
4. The common man cannot afford food items with their original constituents.
5. Lack of trained manpower with outdated food processing techniques.

Most Commonly Adulterated Foods

Name of Food Article	Adulterant
Milk	Water and starch, removal of fat
Ghee and Butter	Vanaspati or margarine, mashed potatoes, sweet potatoes and other starches
Oils and Fats	Argemone oil, mineral oil and castor oil
Sugar	Chalk powder and washing soda
Honey	Sugar solution
Sweets, Icecreams and beverages	Metanil yellow (a non permitted coal tar colour) and saccharin
Wheat, Rice, Maize, Jawar, Bajra, Chana, Barley, etc.	Dust, pebble, stone, straw, weed seeds, damaged grain, weevilled grain, insects, rodent hair and excreta.
Dal whole and spilt	Khesari Dal, clay, stone, gravels, webs, insects, rodent hair and excreta
Atta, Maida, Suji (Rawa)	Sand, soil, insects, webs, lumps, rodent hair and excreta
Whole spices	Dirt, dust, straw, insect, damaged seeds, other seeds, rodent hair and excreta
Black pepper	Papaya seeds

FOOD SCIENCE (MCQS)

Note: Answers are Bold and Underlined:

1. **Which of the following vitamins is associated with coagulation of blood?**
(a) Vitamin A (b) Vitamin B (c) Vitamin E (d) **Vitamin K**

2. **In animals, the principal role of Vitamin E is:**
(a) **Antioxidant** (b) Reproduction (c) Digestion (d) Transpiration

3. **Which of the following is not a vitamin?**
(a) **Trypsin** (b) Ascorbic add (c) Riboflavin (d) Niacin amide

4. **The richest source of Vitamin A is:**
(a) Orange (b) Apple (c) Eggs (d) **Liver**

5. **Which of the following vitamins is produced in the sun's rays?**
(a) Vitamin A (b) Vitamin B (c) Vitamin C (d) **Vitamin D**

6. **A balanced diet contains:**
(a) Animal protein (b) Macro-and micro-nutrients
(c) **All food nutrients necessary for growth and maintenance**
(d) Butter and ghee

7. **Which of the following does not belong to the vitamin B complex group?**
(a) Thiamine (b) **Ascorbic acid** (c) Riboflavin (d) Folic acid

8. **Which of the following vitamins cannot be stored in the liver?**
(a) Vitamin A (b) **Vitamin C** (c) Vitamin D (d) Vitamin K

9. **Which vitamin is known as ascorbic acid?**
(a) A (b) B (c) K (d) **C**

10. **The number of Amino acids that constitute all proteins is about:**
(a) 10 (b) 15 (c) **20** (d) 25

11. **Which of the following vitamins is water soluble?**
(a) A (b) **B** (c) E (d) K

12. **Which of the following is used as a food preservative?**
(a) Sodium benzoate (b) Acetic Acid
(c) Citric acid (d) **All of these**

13. **Albumin is:**
(a) **Egg protein** (b) Milk protein
(c) Egg fat (d) None of these

14. **Yeast is used in making bread because it produces:**
(a) **CO_2** (b) Sugar (c) Bacteria (d) Oxygen

15. **Enzymes are formed of**
(a) Amino acids (b) Fats (c) Carbohydrates (d) **Proteins**

16. **Man cannot survive without taking minimum amount of:**
(a) Proteins (b) **Carbohydrates** (c) Fats (d) Minerals

17. **Pasteurized milk is:**
(a) **Specially treated milk in order to kill bacteria**
(b) Milk mixed with protein rich powder
(c) Milk rich in fats (d) Medicated milk for children

18. **Deficiency of vitamin C causes:**
(a) Night-blindness (b) Beri-Beri (c) **Scurvy** (d) Rickets

19. **Each gram of fat metabolized by the body releases about __________ calories.**
(a) 4 (b) 5 (c) 7 (d) **9**

20. **Which of these carbohydrates provides fibre, or "roughage" in humans?**
(a) Sucrose (b) Starch (c) Glycogen (d) **Cellulose**

21. **All of these carbohydrates come from plants EXCEPT:**
(a) Cellulose (b) Fructose (c) **Lactose** (d) Maltose

22. **Complex carbohydrates:**
(a) Include glycogen, cellulose, and starch.
(b) Consist of many glucose molecules bound together in long chains.

(c) Are polysaccharides. (d) **All of these**

23. The brain relies almost entirely on ________ for energy production.

(a) Insulin (b) **Glucose** (c) Protein (d) Fatty acids

24. For long-term storage, glucose is converted into ________, while for short-term storage, glucose is converted into:

(a) **Fat, glycogen** (b) glycogen, ketone bodies

(c) Glycogen, protein (d) Pyruvic acid, fat

25. All other monosaccharides absorbed into the blood are converted into ________ in the liver.

(a) Fructose (b) Galactose (c) **Glucose** (d) Sucrose

26. Skeletal muscle cells derive most of their energy from:

(a) **Glucose** (b) Triglycerides (c) Glycogen (d) Proteins

27. Which of these carbohydrates is a disaccharide composed of two glucose molecules?

(a) Sucrose (b) Galactose (c) **Maltose** (d) Lactose

28. Fish, safflower oil, sunflower oil, and corn oil are sources of:

(a) Monounsaturated fat (b) **Polyunsaturated fat**

(c) Saturated fat (d) Steroids

29. All of these foods contain cholesterol EXCEPT:

(a) **Coconut oil** (b) Butter (c) Cheese (d) Eggs

30. Good Cholesterol is also called:

(a) LDL (b) **HDL** (c) ATP (d) ADP

31. There are ________ amino acids in proteins, and ________ are considered to be essential amino acids.

(a) 30, 12 (b) 20, 12 (c) **20, 9** (d) 12, 9

32. All of these are examples of proteins in the body EXCEPT:

(a) Collagen (b) Enzymes (c) Haemoglobin (d) **Lecithin**

33. The two vitamins necessary for nucleic acid synthesis are folate and:

(a) Vitamin A (b) Vitamin B1 (thiamine)

(c) Vitamin B3 (niacin) (d) **Vitamin B12 (cobalamin)**

34. The energy currency of the cell is:

(a) Fat (b) **ATP** (c) ADP (d) Enzymes

35. About 99% of the body's energy storage is in the form of:

(a) Amino acids (b) Glucose (c) Glycogen (d) **Lipids**

36. The gain or loss of heat as infrared energy between two objects that are not in physical contact with each other is called:

(a) Convection (b) Evaporation. (c) **Radiation.** (d) Conduction.

37. Osteomalacia can occur as a result of a:

(a) Vitamin C deficiency (b) **Vitamin D deficiency**

(c) Lack of thyroid hormone (d) Lack of growth hormone

38. **Glycogen is mainly stored in:**

(a) Cartilage and bone (b) **Liver and muscles** (c) Spleen (d) Villi

39. **Anaemia is caused in man due to the deficiency of:**

(a) **Folic acid** (b) Vitamin A (c) Vitamin C (d) None of these

40. **The rich source of iron is:**

(a) Eggs (b) **Green vegetables** (c) Pulses (d) Milk

41. **What are the common antioxidant substances?**

(a) Beta-carotene (b) Lutein

(c) Lycopene (d) **All of these**

42. **What are the common everyday foods that are rich in antioxidants?**

(a) Fruits Berries (b) Black Tea

(c) Fruits and veggies (d) **All of these**

43. **Ancient methods of food preservation include:**

(a) Pasteurizing and sterilizing (b) Canning, blanching, and irradiating

(c) Freezing and boiling (d) **Drying, smoking, and fermenting**

44. **A biological method of food preservation is:**

(a) Freezing (b) Drying (c) **Fermentation** (d) Adding salt

45. **Food additives may be used to:**

(a) Destroy nutrients (b) Disguise faulty products

(c) Deceive customers (d) **Enhance appearance**

46. **Substances used to preserve foods by lowering the pH are:**

(a) **Vinegar and citric acid** (b) Smoke and irradiation

(c) Baking powder and soda (d) Salt and sugar

47. **An essential amino acid:**

(a) Forms a complete protein.

(b) Is needed only by growing infants and children.

(c) May prevent dermatitis.

(d) **Cannot be synthesized by the body to meet the body's needs.**

48. **The order of amino acids in a specific protein determines its:**

(a) Energy content (b) **Function in the body**

(c) Biological value (d) Ability to form glucose

49. **Which of the following is definitely not a protein?**

(a) Antibody (b) Enzyme

(c) Tendon (d) **Glycogen**

50. **Which one of the following food items is the richest in protein?**

(a) Butter (b) Wheat (c) Soybean (d) **Fish**

CHAPTER 9

CELL BIOLOGY

Cell is the unit of structure and function of all living things. The cells that make up our body are so small that one cannot see a single cell with a naked eye. The word cell is derived from the Latin word "cellula" which means "a little room". Organisms can be classified as *unicellular* (consisting of a single cell; including bacteria) or *multicellular* (including plants and animals). The cell was discovered by Robert Hooke in 1665. **Cytology** is the study of all aspects of a cell.

Cells are often divided into particular groups based on major characteristics. One such division separates cells into two groups: **prokaryotic** and **eukaryotic cells.** Prokaryotic cells are much smaller and simpler than eukaryotic cells.

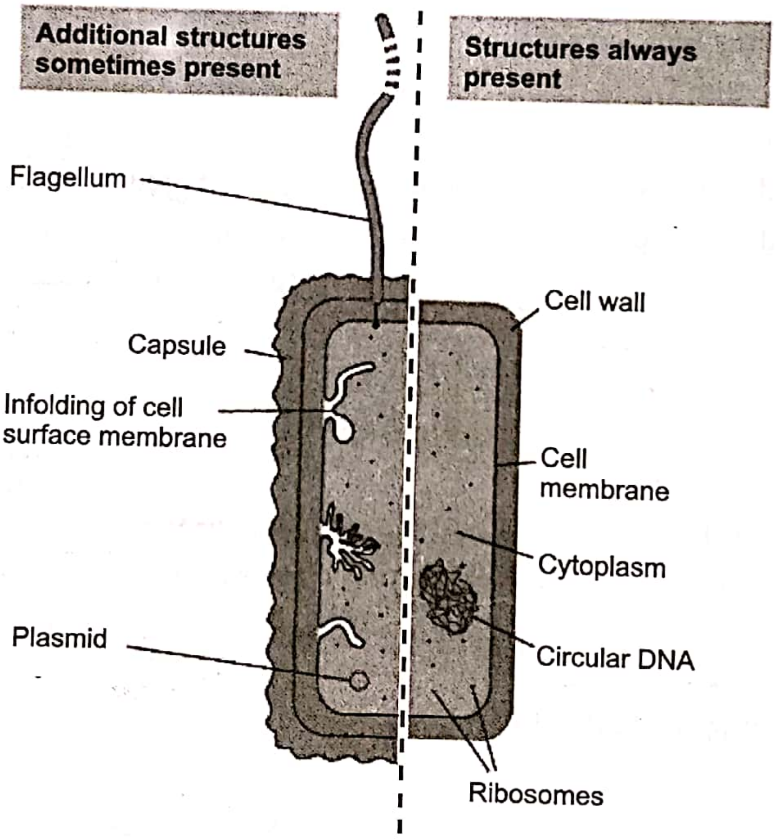

Additional structures sometimes present
Structures always present
Flagellum
Capsule
Infolding of cell surface membrane
Plasmid
Cell wall
Cell membrane
Cytoplasm
Circular DNA
Ribosomes

Figure: Prokaryotic Cell

Prokaryotes, which include all bacteria and archaea (archaebacteria), are the simplest cellular organisms. Prokaryotic cells are fundamentally different in their internal organization from eukaryotic cells. Notably. Eukaryotic cells contain a membrane-bound nucleus and numerous membrane-enclosed organelles (e.g., mitochondria, lysosomes, Golgi apparatus) not found in prokaryotes.

Compare prokaryotic and eukaryotic cells

Similarities

1. They both have DNA as their genetic material.
2. They both are membrane bound.
3. They both have ribosomes.
4. They have similar basic metabolism.
5. They are both amazingly diverse in forms.

Differences

1. Eukaryotes have a nucleus, while prokaryotes do not
2. Eukaryotes have membrane-bound organelles, while prokaryotes do not. The organelles of eukaryotes allow them to exhibit much higher levels of intracellular division of labour than is possible in prokaryotic cells.
3. Eukaryotic cells are, on average, ten times the size of prokaryotic cells.
4. The DNA of eukaryotes is much more complex and therefore, much more extensive than the DNA of prokaryotes.
5. Prokaryotes have a cell wall composed of peptidoglycan, a single large polymer of amino acids and sugar. Many types of eukaryotic cells also have cell walls, but none made of peptidoglycan.
6. The DNA of prokaryotes floats freely around the cell; the DNA of eukaryotes is held within its nucleus and associated with histones (proteins)
7. Eukaryotes undergo mitosis; prokaryotes divide by binary fission (simple cell division)
8. Animals, plants, fungi, and protists are all eukaryotes. While bacteria are prokaryotes.

CELL ORGANELLES

Common organelles include the following

- Endoplasmic reticulum
- Ribosomes
- Lysosomes (not usually found in plant cells)
- Golgi apparatus
- Mitochondria
- Nucleus

- Chloroplasts (only in plant and algal cells)
- Centrosomes (in all eukaryotic cells, but centrioles are not found in some plant cells)
- Vacuoles

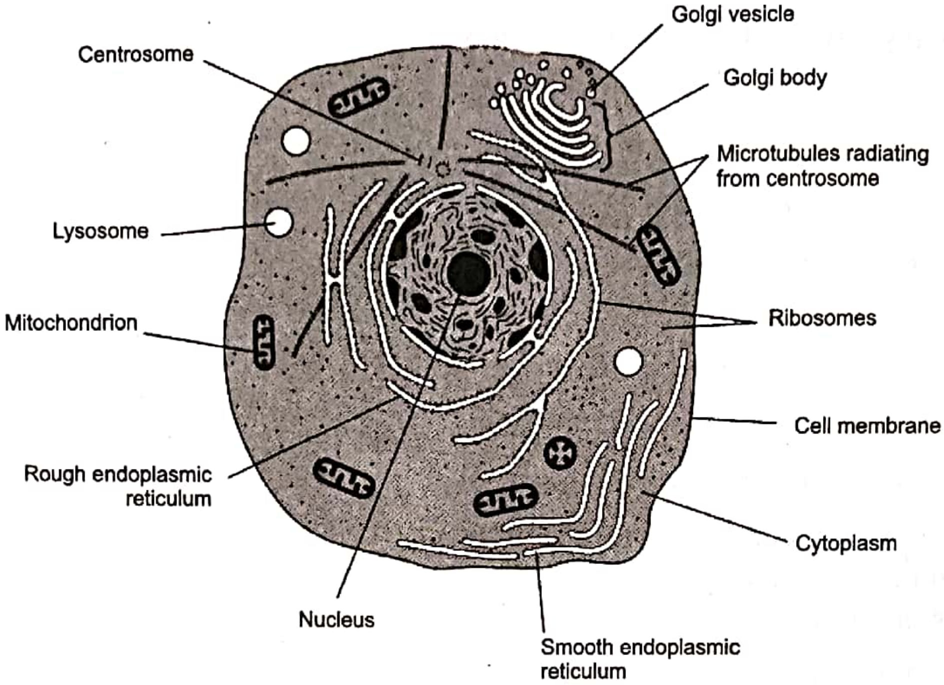

Golgi vesicle
Centrosome
Golgi body
Microtubules radiating from centrosome
Lysosome
Mitochondrion
Ribosomes
Cell membrane
Rough endoplasmic reticulum
Cytoplasm
Nucleus
Smooth endoplasmic reticulum

Figure: Animal cell

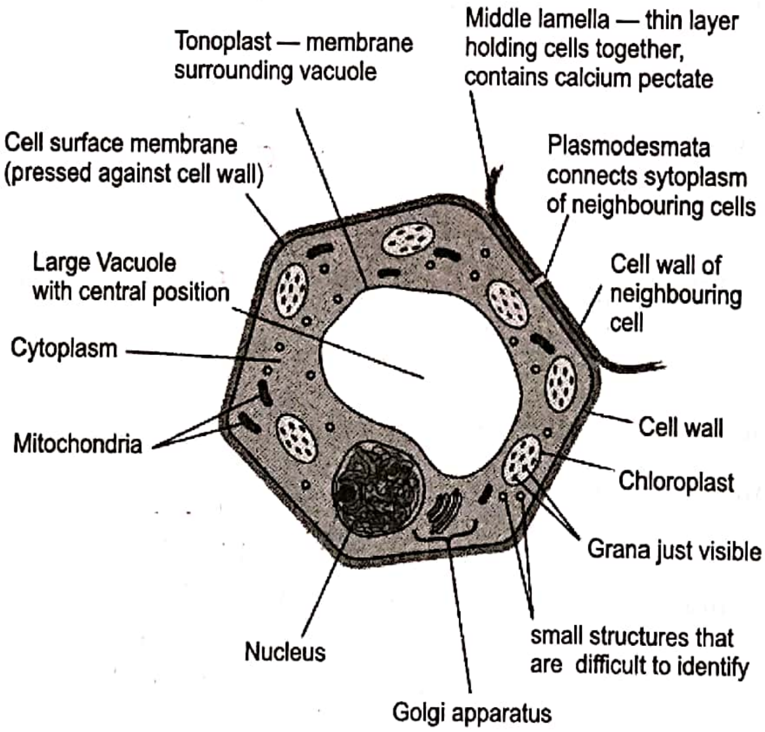

Tonoplast — membrane surrounding vacuole
Middle lamella — thin layer holding cells together, contains calcium pectate
Cell surface membrane (pressed against cell wall)
Plasmodesmata connects sytoplasm of neighbouring cells
Large Vacuole with central position
Cell wall of neighbouring cell
Cytoplasm
Mitochondria
Cell wall
Chloroplast
Grana just visible
Nucleus
small structures that are difficult to identify
Golgi apparatus

Figure: Plant cell

PLASMA MEMBRANE

Plasma membrane or cell membrane is the outer most boundary of a cell. However, in plant cell it is covered by cell wall.

Structure of Plasma Membrane (Fluid Mosaic Model)

One of the things that all cells have in common is a cell membrane. It is a barrier that separates a cell from its surrounding environment. This outer boundary of the cell is also called the plasma membrane. It is composed of four different types of molecules:

1. Phospholipids
2. Cholesterol
3. Proteins
4. Carbohydrates

The **fluid mosaic model** describes the structure of a cell membrane. It indicates that the cell membrane is not solid. It is flexible and has a similar consistency to vegetable oil, so all the individual molecules are just floating in a fluid medium, and they are all capable of moving sideways within the cell membrane. Mosaic refers to something that contains many different parts. The plasma membrane is a mosaic of phospholipids, cholesterol molecules, proteins and carbohydrates.

The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary with cell type. For example, myelin contains 18% protein and 76% lipid. The mitochondrial inner membrane contains 76% protein and 24% lipid.

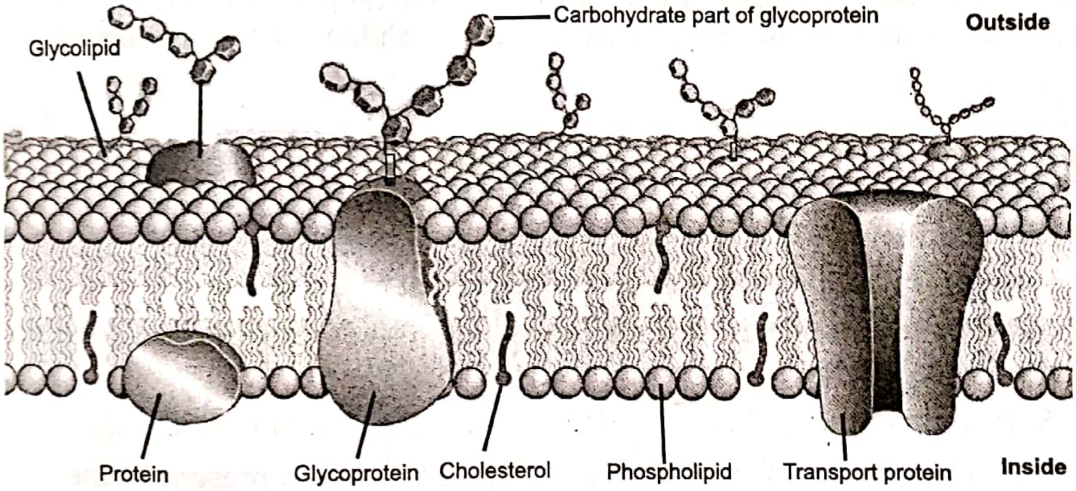


Figure: Fluid Mosaic Model

Functions of Plasma Membrane

1. **Transport of Material:** Transport of materials is an important function of the plasma membrane. It forms a barrier between the cell contents and outer environment.
2. **Differentially permeable membrane:** The plasma membrane allows only selective substance to pass through it. So it is called differentially permeable or selectively permeable membrane.
3. **Maintenance of concentration gradient:** The plasma membrane regulates the flow of materials and ions. So it maintains a definite concentration gradient. Lipid soluble

substance easily cross the membrane. Similarly, much small gas molecules, water, glucose, etc. are neutral compounds. So they easily cross the membrane. On the other hand, ions like Na+, K+ are charged particles. So they cannot cross membrane easily. Thus, there is unequal distribution of substance between inside and outside the cell. It causes concentration gradient.

4. **Endocytosis:** The intake of the food material by infolding of the membrane in the form of vacuole is called Endocytosis. It takes place in many animal cells. These are types of endocytosis.

   (a) Phagocytosis or cell eating: In this case, solid particles are engulfed by infolding membrane.

   (b) Pinocytosis or cell drinking: In this case, liquid material is taken inside by infolding.

5. **Transmission of nerve impulses:** The cell membrane of the neurons (nerve cells) transmits the nerve impulses from one part of the body to the other part. It takes coordination in the body.

CYTOPLASM

The living content of the protoplasm between plasma membrane and nucleus is cytoplasm. These living contents (nucleus and cytoplasm) collectively from **protoplasm**. The cytoplasm has two parts organelles and cytosol.

Organelles and Inclusions

It contains different cell organelles like mitochondria, golgi bodies, endoplasmic reticulum, lysosomes, etc. It also contains insoluble inclusions like insoluble waste and storage products.

Cytosol

The soluble part of the cytoplasm is called cytosol. It forms the ground substance of the cytoplasm. Chemically, it has about 90% water. It contains all fundamental molecules of the cells. These molecules are present in two forms:

- **True solution:** The small molecules and ions from true solution.
- **Colloidal solution:** Some large molecules and ions from colloided solution. Colloidal solution is present in two forms.
  - **(a) Sol:** Non-viscous colloidal solution is called sol. It is present in liquid form.
  - **(b) Gel:** The viscous colloidal solution is called gel. It is present in the form of semi-solid. The peripheral part of cell is often like a gel.

Function of Cytoplasm

Cytoplasm performs following functions:

1. It acts as storage house. Most of important compounds like starch are stored in the cytoplasm.
2. Some metabolic processes like glycolysis (breaking of glucose) take place in the cytoplasm.

3. The cytoplasm contains several cell organelles like mitochondria, golgi bodies, endoplasm reticulum, lysosomes, etc. These cell organelles perform many important function of the cells.
4. Cytoplasm shows streaming movements. Streaming movement is an active mass movement of cytoplasm. Many free floating organelles like mitochondria move in the cytoplasm due to these streaming movements.

NUCLEUS

Nucleus was discovered by Robert Brown in 1831. It is a prominent body in many cells. It looks dark than that of surrounding cytoplasm. The shape of nucleus may be irregular or spherical. It controls the life activities of the cell. It is generally present in the centre of animal cells. The plant cells have a large vacuole. So their nucleus is pushed towards the periphery. Their number is different in different cells:

- **Mononucleate:** Generally, the cells have one nucleus. Such cells are called mononucleate.
- **Binucleate:** The cells with two nuclei are called binucleate.

The nucleus is visible only during non-dividing stage. During non-dividing stage, the nucleus is composed of chromatin network and nucleoplasm. The nucleus disappears and the chromatin material is replaced by chromosomes in the dividing cells. Chemically, the nucleus is composed of four parts: nuclear membrane, nucleoli, nucleoplasm and chromosomes.

Nuclear Membrane

The nucleus is surrounded by nuclear membrane. It separates the nuclear material from the cytoplasm. The nuclear membrane is actually a nuclear envelope as it is composed of two membranes. The outer membrane is continuous with the endoplasmic reticulum at certain points. The inner membrane encloses the nuclear contents. The outer and inner membranes are discontinuing at certain points. So, they form pores, called nuclear pores. The nuclear pores allow the exchange of material between the nucleus and cytoplasm.

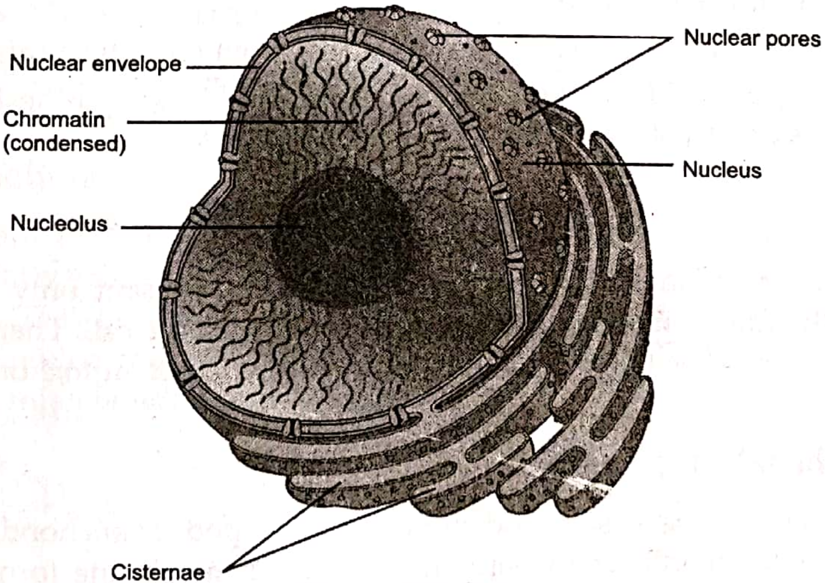


Figure: Nucleus

Nucleolus

It is darkly stained body within the nucleus. It is without any membranous boundary, which separates it from the other nuclear material. The nucleus may contain one or more nucleoli. Nucleolus synthesizes and stores ribosomal RNA (rRNA).:

The ribosomes are assembled in the nucleolus. These ribosomes are exported to cytoplasm through nuclear pores.

Chromosomes

The nucleus contains chromatin material. This chromatin material is deeply stained with basic dye. This chromatin is changed into chromosomes during cell division.

The chromosome is made up to two arms and centromere. Each chromosome has two identical chromatids at the beginning of cell division. The chromatids are exact replica (copy) of each other. These chromatids are attached with each other at centromere. The chromatids are attached with the spindle fibres at centromere during cell division.

All the individual of the same species have constant numbers of chromosomes. These chromosomes remain constant generation after generation.

- Man has 46 chromosomes.
- Frog has 26 chromosomes.
- Chimpanzee has 48 chromosomes.
- Fruit fly (*Drosophila melanogaster*) has 8 chromosomes.
- Onion has 16 chromosomes.

Nucleoplasm

It forms soluble nuclear sap (soluble fluid) inside the nucleus.

Functions of Nucleus

Nucleus performs following functions:

1. It controls all the activities of the cells.
2. It controls the transfer of hereditary characters from parents to offspring.
3. The three types of RNAs, i.e. mRNA, tRNA, rRNA are synthesized in the nucleus. These RNAs are involved in the synthesis of proteins.

MITOCHONDRIA

Mitochondria are very important organelles. They are present only in Eukaryotic cells. They are involved in the manufacturing and supply of energy to the cell. Therefore, mitochondria may be called power house of the cell. The size and number of mitochondria is different in different cells.

Structure of Mitochondria

The mitochondria may be vesicle rod or filament shaped. Mitochondria are bounded by two membranes. The outer membrane is smooth. The inner membrane forms many infoldings, called *cristae*. The inner surface of cristae contains small knob like structure, called F_1 particles. These F_1 particles are suspended inside the matrix.

Chemical Composition of Mitochondria

The mitochondrial membranes have similar composition and structure as other membranes. They are composed of lipids and proteins. The mitochondrial matrix contains a large number of enzymes, coenzymes, organic and inorganic salts. Mitochondria also contain DNA and ribosomes. So mitochondria can synthesize their own proteins.

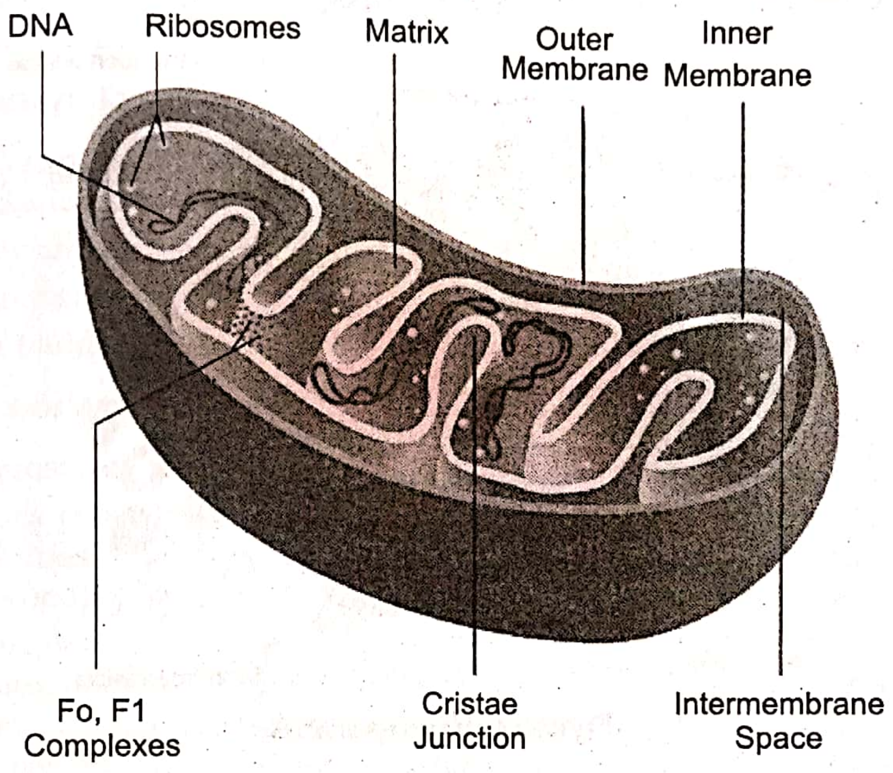


Figure: Structure of Mitochondria

Formation of New Mitochondria

Mitochondria are self-replicating organelles. It means new mitochondria are formed by the division of the old mitochondria.

Functions of Mitochondria

Many important metabolic processes take place in mitochondria. These are kerbs cycle, aerobic respiration, fatty acid metabolism, etc. Energy is released from organic food during these metabolic processes. This energy is transferred to energy rich compound ATP (adenosine tri-phosphate). ATP provides energy to cell on demands and ATP is broken to ADP. This ADP absorbs energy from mitochondria and again becomes ATP.

GOLGI APPARATUS

Golgi apparatus was discovered by Golgi in 1898. Golgi apparatus are present only in eukaryotic cells.

Structure of Golgi apparatus

The Golgi apparatus consists of stacks of sacs. These sacs are flattened and membranous bound. These stacked sacs are called *cisternae*. The cisternae with associated vesicles are called Golgi apparatus or Golgi complex. The Golgi complex system of interconnected tubules is present around the central stacks.

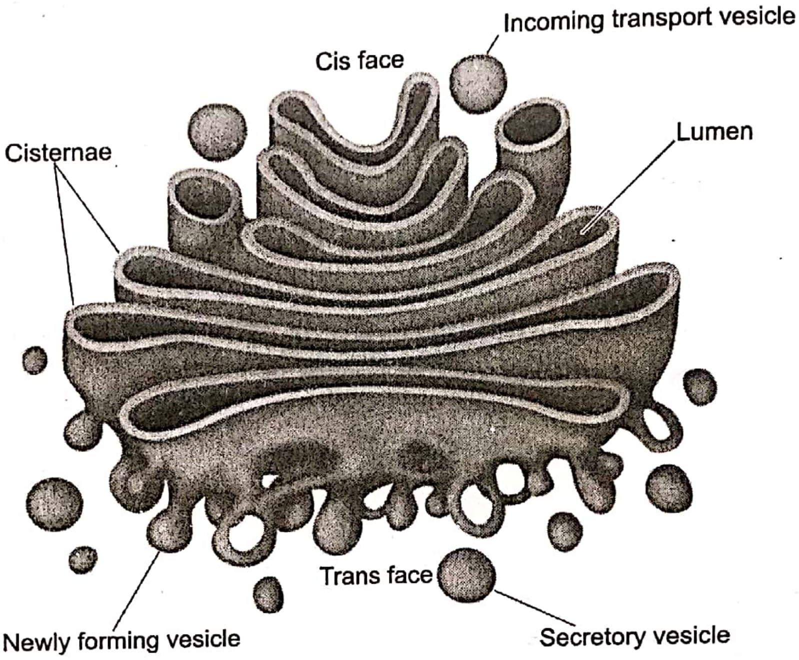


Figure: Golgi apparatus

Function of Golgi apparatus

Golgi complex performs following functions:

1. **Cell secretions:** Golgi complex are concerned with cell secretions. For example, in mammals, the pancreas secretes granules. These granules contain enzymes that help in digestion. Following step are involved in the process of cell secretions:
   - The ribosome's synthesize protein part of the cell secretions.
   - The endoplasmic reticulum transfers it to golgi apparatus.
   - Golgi apparatus converts the secretion to finished products. These secretions are packed inside the membrane to form granules.
   - Finally granules are exported outside by cell membrane.
2. **Transportation:** Golgi apparatus transport the proteins or enzymes outside the cell.
3. **Formation of Glycolipids:** It is the most important function of the Golgi apparatus. They add carbohydrate to protein and lipids to form glycolipids.

LYSOSOMES

Lysosomes were isolated by De Duve in 1949. The word lysosome is formed of two words: *Lyso* means dissolution and *soma* means body. So they are concerned with the breaking activities. These are found only is eukaryotic cells.

Structure of Lysosomes

They are bounded by a single membrane. This membrane forms a simple sac. This sac contains several hydrolytic enzymes like acid phosphatase.

Formation of Primary Lysosomes

1. The enzymes of the lysosomes are synthesized by ribosomes, present on the **rough endoplasmic reticulum** RER.
2. Then they are transferred to golgi apparatus by RER.
3. These enzymes are further processed in the golgi apparatus.
4. They are budded off as golgi vesicles. These vesicles are called primary lysosomes.

Formation of Secondary Lysosomes

Secondary Lysosomes are formed by two methods:

1. Lysosomes protect the body against the invading organisms. They also engulf the food particles. The foreign object (germ or food) fuses with primary lysosomes to form secondary lysosomes. In secondary lysosomes, enzymes digest the food particles.
2. Sometimes, under some abnormal conditions like starvation or normal physiological conditions, the primary lysosomes engulf the parts of cell. It digests these parts and release energy. The lysosomes which eat parts of its own cells are called autophagosomes. These autophaosomes are also secondary lysosomes.

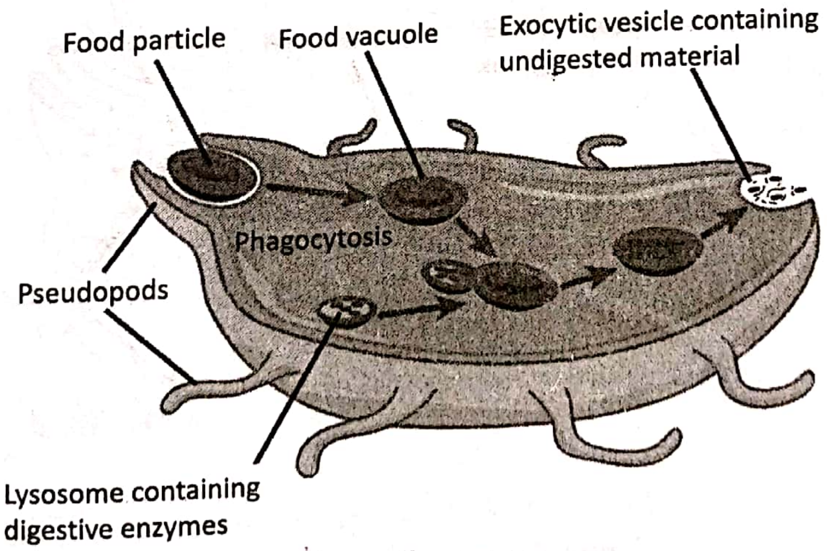

Food particle
Food vacuole
Exocytic vesicle containing undigested material
Phagocytosis
Pseudopods
Lysosome containing digestive enzymes

Figure: Lysosome

Functions of Lysosomes

Lysosomes performs following function:

1. **Phagocytosis:** Any foreign object which tries to enter into cell is engulfed by lysosome. It is broken into digestible pieces. This process is knows as phagocytosis (cell eating). The animals which show phagocytic activity have most abundant lysosomes. Example: amoeba.
2. **Intracellular digestion:** Lysosomes contain enzymes which can digest the phagocytosed food.
3. **Extra cellular digestion:** Lysosomes also release enzymes for extra cellular digestion.
4. **Autophagy (self-eating):** Sometimes, lysosomes break parts of their own cells. It is called autophagy. Cell contains some old, broken parts like old mitochondria. They are digested by the lysosomes. In this way, material of the cell is recycled.
5. **Degeneration of Cells:** The enzymes of cell also cause degeneration of some cells. It may occur during some developmental processes, e.g. sperms or tail in the development of larva of frog is degenerated.
6. **Storage diseases:** Lysosomal storage diseases are a group of approximately 50 rare inherited metabolic disorders that result from defects in lysosomal function.

ENDOPLASMIC RETICULUM

Endoplasmic reticulum is a network of channels present throughout the cell. On their inner side, they are in contact with the nuclear membrane. The entire system of channels is called Endoplasmic reticulum. These channels are composed of spherical or tubular membranes, called *cisternae.* These cisternae separate the material present in the channels from the cytoplasmic materials. The appearance of these membrane is different in different types of cells.

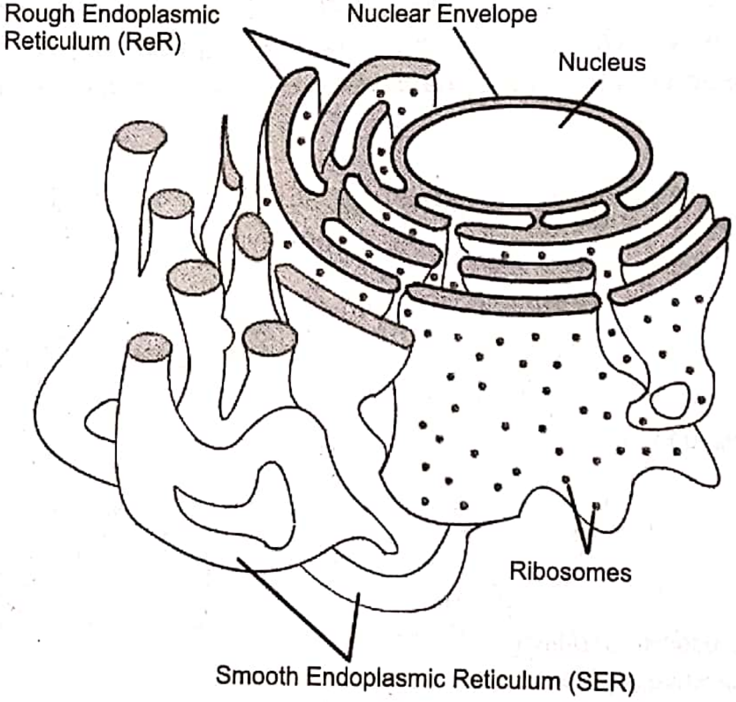

Rough Endoplasmic Reticulum (ReR)
Nuclear Envelope
Nucleus
Ribosomes
Smooth Endoplasmic Reticulum (SER)

Figure: Endoplasmic Reticulum

Types of Endoplasmic Reticulum

There are two types of endoplasmic reticulum. These are:

- **Rough Endoplasmic Reticulum (RER):** Ribosomes are attached with the rough endoplasmic reticulum.
- **Smooth Endoplasmic Reticulum (SER):** They are without ribosomes.

Functions of Endoplasmic Reticulum

Endoplasmic reticulum performs following functions:

1. **Mechanical support:** Endoplasmic reticulum provides mechanical support to the cell. So the shape of cell is maintained.
2. **Transport of material:** The SER are involved in transport of material within the cell.
3. **Synthesis of protein:** The rough endoplasmic reticulum is involved in the synthesis of protein.
4. **Storage of compounds:** Some compounds like proteins are stored temporarily in the endoplasmic reticulum.
5. **Metabolism of lipid:** The smooth endoplasmic reticulum is also involved in the metabolism of lipid.
6. **Detoxification of drugs:** The SER detoxifies the harmful drugs and toxic materials.
7. **Transmission of Nerve impulses:** The transmission of nerve impulse in muscles and nerve cells takes place by SER.

RIBOSOMES

Ribosomes are tiny granular structures present in cytoplasm. Palade was the first person who studied ribosomes in 1955.

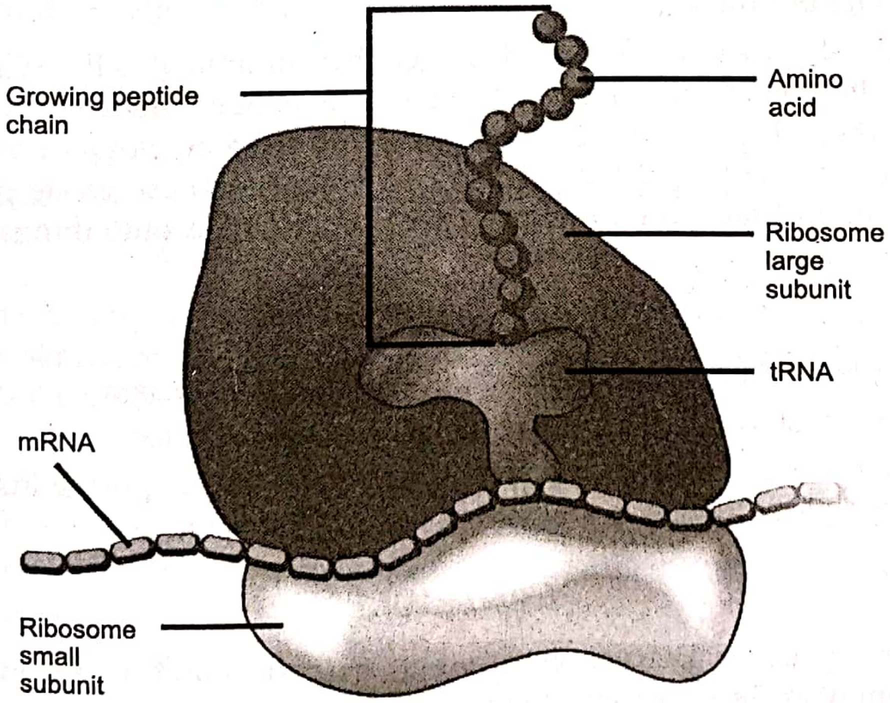


Figure: RNA and Ribosome

1. **Chemical Composition:** Ribosomes of eukaryotes are composed of ribonucleoprotein. The ribonucleoprotein contains equal amount of RNA and protein. The RNA in ribosome is ribosomal RNA (rRNA).
2. **Occurrence of Ribosomes:** Ribosomes are present in two form.
    - Freely dispersed form in cytoplasm.
    - Attached with RER as tiny granules.
3. **Sub-units of Ribosomes:** The ribosome of the eukaryotes consists of two sub-units. The large sub unit is 60S. The small sub unit is 40S. "S" is Svedberg unit. "S" is rate of sediment formation during ultracentrifugation. These two sub-units attach with each other to form 80S particle. This attachment is controlled by Mg^{+2} ions. The 40S sub unit controls the attachment of ribosome with mRNA.
4. **Polysome:** A group of ribosomes attached to same **mRNA** is known as polysome.
5. **Formation of Ribosomes:** Ribosomes are synthesized in the nucleolus of the nucleus. The nucleoli are factories of ribosomes. The ribosomes pass through pores in the nuclear membrane and enter the cytoplasm.
6. **Function of Ribosome:** The ribosomes are factories of protein synthesis.

VACUOLES

Vacuoles are storage bubbles found in cells. They are found in both animal and plant cells but are much larger in plant cells. Vacuoles might store food or any variety of nutrients a cell might need to survive. They can even store waste products so the rest of the cell is protected from contamination. Eventually, those waste products would be sent out of the cell.

The structure of vacuoles is fairly simple. There is a membrane that surrounds a mass of fluid. In that fluid are nutrients or waste products. Plants may also use vacuoles to store water. Those tiny water bags help to support the plant. They are closely related to objects called vesicles that are found throughout the cell.

In plant cells, the vacuoles are much larger than in animal cells. When a plant cell has stopped growing, there is usually one very large vacuole. Sometimes that vacuole can take up more than half of the cell's volume. The vacuole holds large amounts of water or food. Don't forget that vacuoles can also hold the plant waste products. Those waste products are slowly broken into small pieces that cannot hurt the cell. Vacuoles hold onto things that the cell might need, just like a backpack.

Functions

1. They expands the plant cells and do not dilute its cytoplasm.
2. They store water, cell products or metabolic intermediates.
3. They cause turgor in plant cell. This turgor provides support to individual plant cells. It creates rigidity in leaves and young parts of the plants.

CENTRIOLES

Centrioles are cylindrical structures present in animals and absent in plants cells. Two centrioles are present near the outer surface of nucleus.

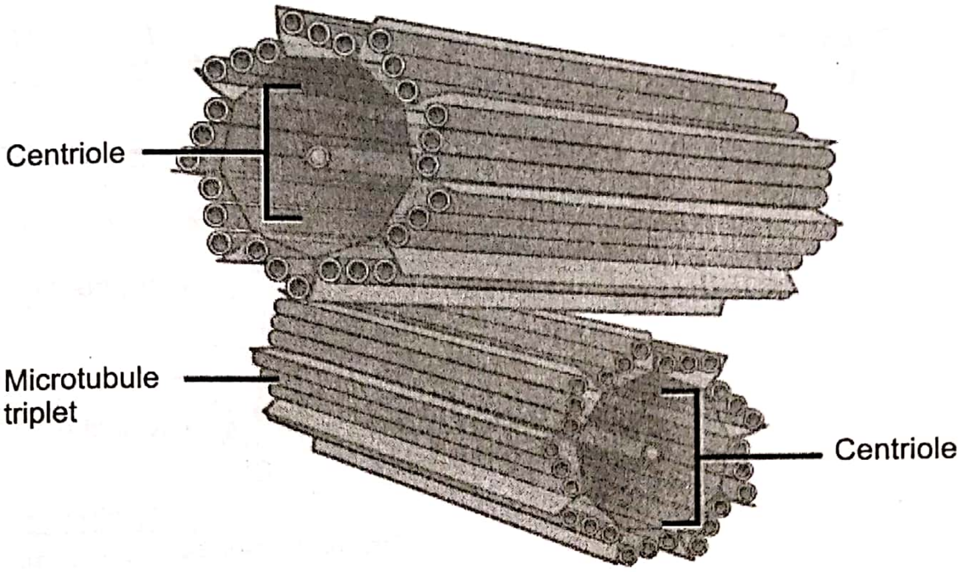


Figure: Centriole

Structure

The centrioles have cylindrical structure. In cross section, nine microtubules are arranged in this cylinder. Each of the nine microtubules is further composed of three tubules. The two centrioles are present at right angle to each other.

Function of Centrioles

1. The centrioles are involved in **cell division.** The two centrioles duplicate just before cell division and forms two pairs. Each pair moves to the opposite side of the nucleus. The spindle is formed between them.
2. The centrioles play an important role in furrow formation during cell division.
3. The centrioles also play an important role in the **formation of cilia.**

PLASTIDS

The membranous bound and pigment containing bodies present in the plant cell are called plastids. There are three types of plastids: Chloroplast, Chromoplast and Leucoplast.

Chloroplast

The membrane bound structure, containing green pigment is called chloroplast. The chloroplasts are present only in photosynthetic plants. Chloroplasts are self-replicating organelles. Chloroplast contain the greed pigment called chlorophyll.

Chlorophyll: The green pigment is an organic compound called chlorophyll. It helps the plant to absorb light energy and manufacture food. Chlorophyll molecule resembles with the Haem group of haemoglobin. Haemoglobin is a protein which transports oxygen in animals. There is a main difference between two molecules. The central atom of chlorophyll is Mg^{++}, while the central atom of haem is Fe^{++}.

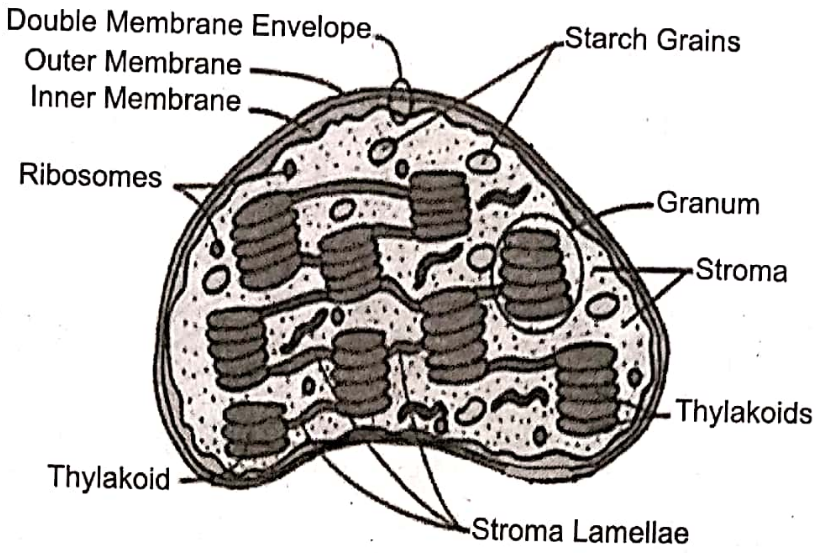


Figure: Structure of Chloroplast

Structure of Chloroplast

The chloroplast shows four main components under electron microscope. These are envelope, stroma, thylakoid and granum.

1. **The Envelope:** It is outer covering of the chloroplast. It formed by a double membrane.
2. **Stroma:** It is a fluid that surrounds the thylakoids. It covers most of the volume of the chloroplast. It contains proteins, some ribosomes and a small circular DNA. The CO_2 is fixed and sugars are synthesized in stroma.
3. **Thylakoids:** These are flattened vesicles. Thylakoids arrange themselves to form grana and intergana.
4. **Granum:** A granum is pile of thylakoids, stacked on each other like coins. On the average, 50 or more thylakoids are piled to form one granum. The chlorophyll molecules are arranged on the layers of thylakoids. So grana appears green. The light energy is trapped by the membrane of grana.
5. **Intergranum:** The grana are interconnected with each other by the non-green part, called intergranum.

Chromoplast

Chromoplasts give colour to plants other than green. They are present in the petals of flowers and in the ripened fruits. They help in pollination and dispersal of seeds.

Leucoplasts

They are colourless. Their shapes may be triangular, tubular or some other. They are found in the underground parts like root of the plant and store food.

DIFFERENCE BETWEEN ANIMAL AND PLANT CELL

Animal Cell	Plant Cell
Cell wall is absent and cellulose in any form is absent.	Cell wall made up of celluloses is present.
Cytoplasm is denser, more granular and occupies most of the space in the cell.	Cytoplasm is pushed to the periphery and forms a thin lining against the cell wall.
There are small vacuoles concerned with excretion or secretion.	The central space in the cell may be occupied by a large, single vacuole.
Nucleus is present at the centre.	Nucleus is not at the centre due to large size of vacuole.
Plastids are absent in animal cells.	Plastids are usually present in plant cell.
Centrioles are present in animal cells.	Centrioles are absent in plant cell.
Glycogen is reserve food in animal cells.	Starch is reserve food in plant cell.
Usually smaller in size and in different shapes.	Usually larger in size and are rectangular.
Cilia are present in animal cells.	Cilia are rarely present in plant cell.

CHROMOSOMES

"We have discovered the secret of life!" Francis Crick

Chromosomes are thread-like structures located inside the nucleus of animal and plant cells. Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA). Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.

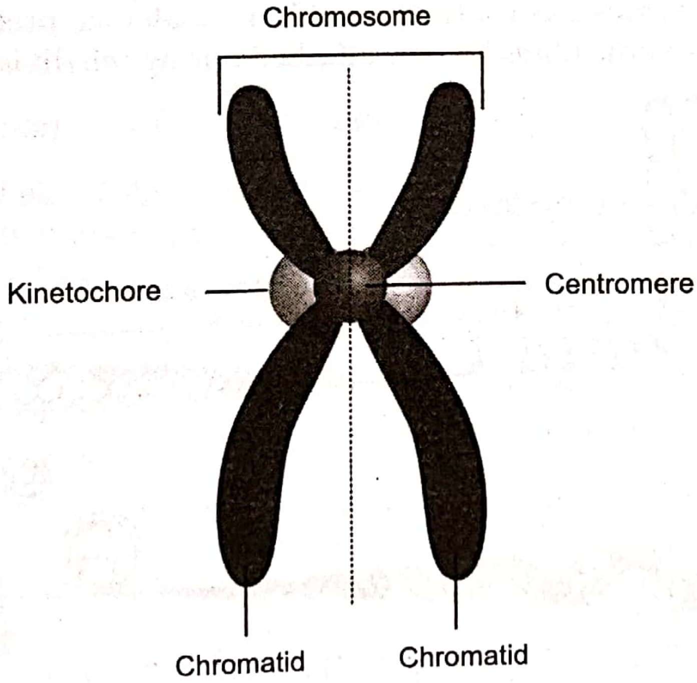


Figure: Chromosome

In the cells of most organisms that reproduce sexually, chromosomes occur in pairs: One chromosome is inherited from the female parent, and one is inherited from the male parent. The two chromosomes of each pair contain genes that correspond to the same inherited characteristics. Each pair of chromosomes is different from every other pair in the same cell.

The number of chromosome pairs in an organism varies depending on the species. The number of chromosomes characteristic of a particular organism is known as the **diploid** number. Dogs, for example, have 39 pairs of chromosomes and a diploid number of 78, while tomato plants have 12 pairs of chromosomes and a diploid number of 24.

Sex cells (eggs or sperm) contain only half the number of chromosomes. This reduced number of chromosomes in the sex cells is known as the **haploid** number. During fertilization, an egg and sperm unite to form a cell known as a **zygote**, the first cell of the offspring. The zygote contains the diploid number of chromosomes characteristic of the species.

The 46 chromosomes of the human cell occur in pairs. Thus, we may say that there are two sets, with 23 chromosomes in each set. Scientists number these chromosome pairs according to their size — the largest is chromosome 1 and the smallest chromosome is 23rd. while, 22 chromosomes humans deal with the body in general called *autosomal chromosomes*. The last pair that is 23rd pair is called the *sex chromosome*. 23rd pair is XX in female and XY in male.

Do you know?

The organism with the greatest number of chromosomes is the Indian fern, which has 1,260 chromosomes. The minimal number of chromosomes is found in Ascaris, a roundworm. It contains only one pair of chromosome.

Structure of Chromosomes

Chromosome consists of two identical components called chromatids, which are held together at a specific region called **primary constriction**. It is usually found in the centre and hence it is commonly described as **centromere**. It has a plate-like proteinaceous structure called **kinetochore** where the spindle fibres become attached during cell division.

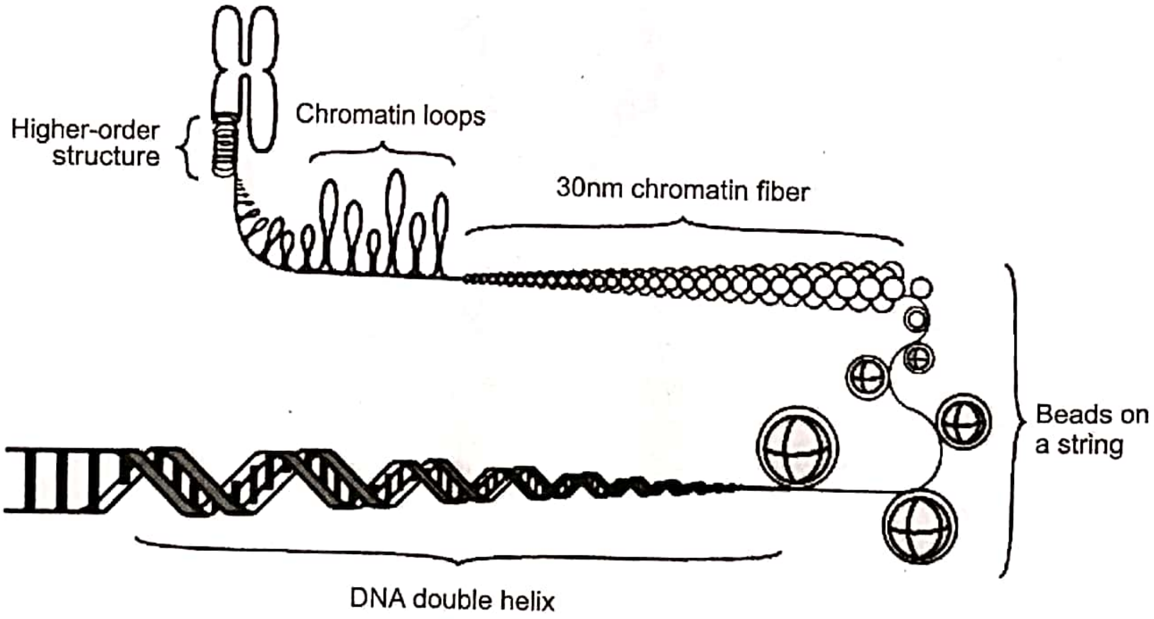


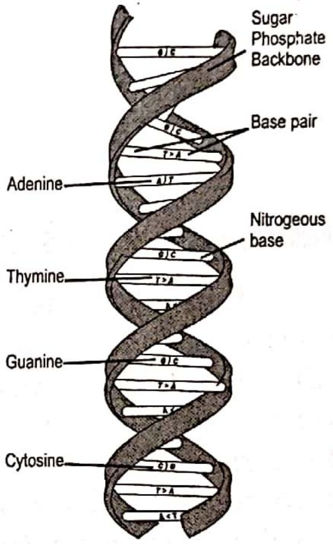
Figure: Structure of Chromosome

The chromosome, when observed under the electron microscope, appears to be composed of a very fine filamentous structure called **chromonema**. The chromonema occurs in a highly coiled state. The chromonema is in turn composed of a chain of tiny, bead-like structures called **nucleosomes**. A nucleosome consists of a core particle surrounded by a DNA strand. The core particle is formed by a group of proteins called histones.

NUCLEIC ACIDS

Nucleic acids are biological molecules essential for known forms of life on this planet; they include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Nucleic acids (both RNA and DNA) are polymers made up of monomers called nucleotide units. The **nucleotide** units themselves are made up of a phosphate unit, a sugar and a nitrogenous base.

Deoxyribonucleic Acid (DNA)



Deoxyribonucleic acid is a nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms. DNA is made of monomers called nucleotides. It was first discovered in 1869 by Swiss Friedrich Mieschler. On February 28, 1953, James Watson of the United States and Francis Crick of England found the double-helical structure of DNA. In 1962, they were awarded Nobel Prize for this work.

A DNA molecule resembles a twisted ladder. A sugar-phosphate backbone forms the sides of the ladder. The phosphate group of one nucleotide is covalently bonded to a hydroxyl group on the sugar of the next. Hydrogen bonding between bases creates the rungs of the ladder. Each strand has a free phosphate group at the 5' end and a free hydroxyl group at the 3' end. The numbers refer to the carbons in the sugar part of each nucleotide.

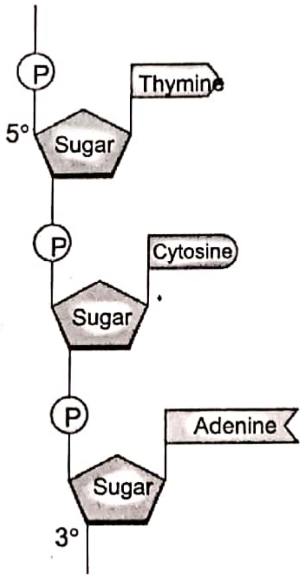
Salient Features of Watson and Crick Model of DNA

- DNA is a double helix with two right handed helical polydeoxy ribonucleotide strands twisted around the same central axis.
- These two strands are held together by hydrogen bonds.
- Adenine always pairs with thymine while guanine always pairs with cytosine.
- AT (Adenine-Thymine) pair has 2 hydrogen bonds while GC (Guanine-Cytosine) pair has 3 hydrogen bonds. Hence, $G \equiv C$ is stronger than $A=T$.
- The amount of adenine is equal to the amount of thymine and the amount of guanine is equal to the amount of cytosine.
- The genetic information is present only on one strand known as template strand.

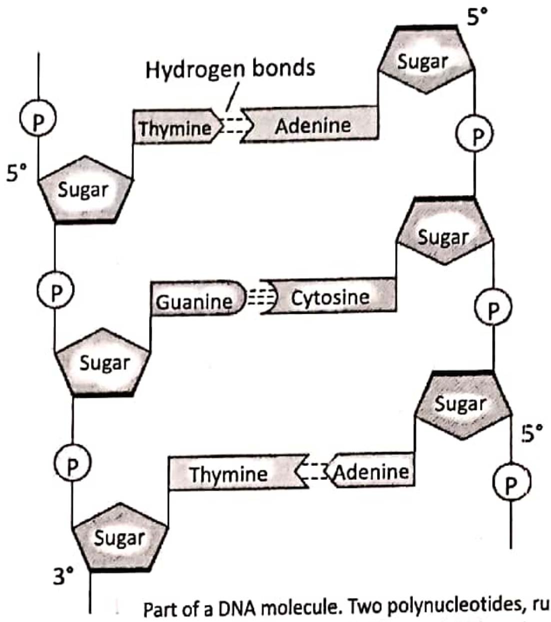
Mnemonic Device
Nitrogenous Bases

"AT GC University."

Adenine, thymine, guanine, cytosine and uracil. Students shall keep it in mind that DNA contains Adenine, thymine, guanine and cytosine and adenine always pair with thymine while guanine always pair with cytosine. RNA contains uracil instead of thymine.



Part of a polynucletid. Each nucleotide is linked to the next by covalent bonds between the phosphates and sugars.



Part of a DNA molecule. Two polynucleotides, running in opposite derections, are held together by hydrogen bons between the bases. A links with T by two hydrogen bons; C links with G by three hydrogen bons. This is complementary base pairing.

Ribonucleic Acid (RNA)

Like DNA, RNA consists of a chain of chemical compounds called nucleotides. Each nucleotide is made up of a sugar molecule called ribose, a phosphate group and one of four different nitrogen-containing compounds called bases. The four bases are adenine, guanine, uracil and cytosine. These components are joined together in the same manner as in a deoxyribonucleic acid (DNA) molecule. RNA differs chemically from DNA in two ways: The RNA contains Ribose sugar while DNA contains Deoxy ribose sugar, and RNA contains the base uracil in the place of the base thymine in DNA.

Types of RNA

RNA occurs mostly in the cytoplasm in the eukaryotic cells. A small amount occurs in the nucleus of the cell, as a constituent of nucleolus. There are three types of RNA: ribosomal RNA, messenger RNA and transfer RNA. Each plays a different role in protein synthesis, the process by which cells combine amino acids to produce proteins.

Ribosomal RNA (rRNA) is the RNA component of the ribosome. It is the site of protein synthesis in all living cells. Ribosomal RNA provides a mechanism for decoding mRNA into amino acids and interacts with tRNAs during translation.

Messenger RNA (mRNA) is created by deoxyribonucleic acid (DNA). DNA contains the instructions for the creation of proteins. Messenger RNA transports these instructions from DNA out of the nucleus to the cytoplasm, where the mRNA attaches to the cell's ribosome. These instructions are present in the forms of codes called codon.

Transfer RNA (tRNA) carries individual amino acids to the mRNA-ribosome complex. The tRNAs are instructed by mRNA to string together specific amino acids at the mRNA-ribosome structure. In this way, a particular sequence of amino acids forms that produces a protein with a specific function.

Difference between DNA and RNA

DNA	RNA
DNA stands for deoxyribonucleic acid.	RNA stands for ribonucleic acid.
DNA has deoxyribose sugar.	RNA has ribose sugar.
Typically a double-stranded molecule with a long chain of nucleotides.	A single-stranded molecule and has a shorter chain of nucleotides.
DNA contains four nitrogenous bases: adenine, guanine, cytosine and thymine.	RNA contains four nitrogenous bases: adenine, guanine, cytosine and uracil.
In DNA pairing occurs as follow: A = T (Adenine-Thymine) and G ≡ C (Guanine-Cytosine).	In RNA pairing occurs as follow: A = U (Adenine-Uracil), G ≡ C (Guanine-Cytosine).
DNA prepares its copies through a process called replication.	DNA prepares the copies of mRNA through a process called transcription.
DNA is a genetic material of all eukaryotes.	RNA is also genetic material of some bacteria and viruses.
DNA is present in the nucleus.	RNA is present in the cytoplasm and nucleus.

CELL BIOLOGY (MCQS)

Note: Answers are Bold and Underlined:

1. **What is a eukaryotic cell?**
   (a) **Cell with a nucleus** (b) Animal Cell
   (c) Cell with no nucleus (d) Plant Cell
2. **What organelle stores waste in cells?**
   (a) Ribosome (b) Mitochondria (c) Golgi body (d) **Vacuole**
3. **In addition to producers and consumers, healthy communities must have ______, bacteria and fungi which recycle materials.**
   (a) Autotrophs (b) **Decomposers**
   (c) Spontaneous Combustion (d) Virus
4. **Each organism has its own _____ or function in a community, and is part of the ________ or web of life.**
   (a) **Niche, Food Chain** (b) Location, Food Chain
   (c) Specialty, Chaos (d) Habitat, Niche
5. **In a typical ecological pyramid, cows are good examples of _____ consumers because they are:**
   (a) **Primary, Herbivores** (b) Secondary, Omnivores

(c) Tertiary, Herbivores
(d) Primary, Carnivores

6. **Bacteria play a vital role in Earth's ecosystems by**
(a) Using oxygen
(b) Producing acetone
(c) **Decomposing dead organisms**
(d) Concentrating valuable minerals

7. **Which of the following is an asexual form of reproduction in bacteria?**
(a) Transformation
(b) Conjugation
(c) Transduction
(d) **Binary Fission**

8. **It has a living, flexible and thin structure. It possesses fine pores, making it semi-permeable.**
(a) Chloroplast
(b) Cytoplasm
(c) Cell Wall
(d) **Cell Membrane**

9. **It has a double-walled structure. Its inner wall is produced into folds known as cristae. It is generally sausage-shaped.**
(a) **Mitochondrion**
(b) Lysosomes
(c) Cell Wall
(d) Golgi apparatus

10. **It is a green-coloured plastid. It contains a pigment called chlorophyll.**
(a) Lysosomes (b) **Chloroplast** (c) Golgi apparatus (d) Centrosome

11. **It has a non-living, rigid structure. It is freely permeable and is chiefly composed of cellulose.**
(a) **Cell Wall**
(b) Leucoplast
(c) Centrosome
(d) Golgi apparatus

12. **It contains most of the cell organelles. It is composed of a mixture of water and soluble organic and inorganic compounds.**
(a) Leucoplast (b) Lysosomes (c) **Cytoplasm** (d) Chloroplast

13. **It is made up of stacks of flattened membranous sacs. It mainly consists of vesicles, vacuoles and tubules.**
(a) Centrosome (b) **Golgi Apparatus** (c) Mitochondrion (d) Cytoplasm

14. **It is a colourless plastid. It contains starch.**
(a) **Leucoplast** (b) Centrosome (c) Golgi Apparatus (d) Chloroplast

15. **The smallest unit of classification of plants and animals is:**
(a) Class (b) Genus (c) Order (d) **Species**

16. **The age of a tree can be determined by:**
(a) Counting the number of branches
(b) Measure the height of the tree
(c) **Counting the number of annual rings in the trunk**
(d) Measuring the diameter of the trunk

17. **Mitochondria is also called**
(a) **Power house of the cell**
(b) Cytoplasm
(c) Centrosome
(d) Plasma lemma

18. **The largest percentage of molecules that make up the cell membrane are**

(a) Carbohydrates, nucleic acids, and proteins

(b) Carbohydrates, water, and nucleic acids

(c) Phospholipids, cholesterol, and proteins

(d) Nucleic acids, amino acids, and fatty acids

19. **In the fluid mosaic model, the double layer (bilayer) of molecules found in the cell membrane is made up of:**

(a) Cholesterol (b) Phospholipids (c) Carbohydrates (d) Nucleic acids

20. **Although the basic structure of the plasma membrane is determined mainly by its __________, the functions of the plasma membrane are determined mainly by its __________.**

(a) Carbohydrates, lipids (b) Carbohydrates, proteins

(c) Lipids, proteins (d) Nucleic acids, lipids

21. **A sequence of nucleotides in DNA that provides a set of instructions for making a functional protein is called a:**

(a) Gene (b) Anticodon (c) Peptide bond (d) mRNA

22. **Transcription takes place in the __________ of the cell.**

(a) Cytosol (b) Golgi apparatus (c) Mitochondria (d) Nucleus

23. **mRNA is copied from**

(a) DNA (b) tRNA

(c) ribosomes (d) polypeptide chains

24. **The __________ on a tRNA molecule pairs with three nucleotides on a mRNA molecule.**

(a) Anticodon (b) Codon (c) Exon (d) Intron

25. **During the process of DNA replication,**

(a) One new DNA strand is formed

(b) The production of new nucleotide strands is catalyzed by DNA ligase

(c) Short segments are spliced together by DNA polymerase

(d) Each new DNA molecule has one strand of nucleotides from the original DNA and one newly synthesized strand

26. **By the process of mitosis in a human cell, __________ daughter cells are produced, each of which has __________ chromosomes.**

(a) 2, 46 (b) 2, 23 (c) 4, 46 (d) 4, 23

27. **Which of these processes is associated with meiosis, but not mitosis?**

(a) DNA replication prior to division (b) Cytokinesis

(c) Crossing over (d) Spindle formation

28. **The process of meiosis:**

(a) Includes meiosis I, II, and III.

(b) Results in the production of sperm cells or oocytes.

(c) Produces 4 diploid cells.

(d) Produces gametes that are identical to the parent cell.

29. **Vacuoles are bound by a definite membrane in plant cells called:**
(a) Plasma membrane (b) **Tonoplast**
(c) Cell wall (d) None of these

30. **The transmission of characters from one generation to next is called:**
(a) **Heredity** (b) Genetics (c) Cytogenesis (d) Variation

31. **The important aspect of genetics is:**
(a) Heredity (b) Variation
(c) Somatic character (d) **Both (a) and (b)**

32. **The father of genetics is:**
(a) Hugo de vries (b) **Mendel** (c) T. H. Morgan (d) Darwin

33. **Mendel worked with which plant to show the transmission of characters:**
(a) Rose (b) Egg plant (c) **Garden pea** (d) Wheat

34. **The real carrier of the genetic information from generation to generation is:**
(a) Proteins (b) **DNA**
(c) RNA (d) Both (b) and (c)

35. **The double helical structure of DNA was proposed by:**
(a) Charles Darwin (b) T. H: Morgan
(c) John Mendel (d) **Watson and Crick**

36. **The two purine bases present in DNA are:**
(a) Adenine and thymine (b) Uracil and cytosine
(c) **Adenine and guanine** (d) Thymine and cytosine

37. **The two pyrimidine bases present in DNA are:**
(a) Adenine and thymine (b) Guanine and cytosine
(c) Adenine and guanine (d) **Thymine and cytosine**

38. **In DNA adenine always pairs with:**
(a) **Thymine** (b) Uracil
(c) Cytosine (d) Either (b) or (c)

39. **In RNA adenine always pair with:**
(a) Thymine (b) **Uracil**
(c) Cytosine (d) Either (a) or (c)

40. **The abbreviation `GMO' stand for:**
(a) **Genetically Modified Organism** (b) Gene Moderator Offices
(c) Generally Modified Organism (d) Genetically Mutated Organ

CHAPTER 10

CLASSIFICATION OF LIVING THINGS

CLASSIFICATION AND TAXONOMY

Nobody knows how many different kinds, or species, of living organisms there are on Earth. About 1.9 million species have been described and named (there). But many biologists think this may be only about one-tenth of all the species on Earth. We have almost certainly discovered most of the large land animals, but there are probably many animals living in the deep oceans which have never been seen by humans. And biologists estimate that there are millions of insects and smaller animals and plants that have not yet been discovered.

"The scientific practice of identifying, naming and grouping of living organisms is called **classification**." The branch of biology that deals with classification is called **taxonomy**. Organisms are grouped together into taxa (singular: taxon) and these groups are given a taxonomic rank; groups of a given rank can be aggregated to form a super group of higher rank, thus creating a taxonomic hierarchy. The Swedish botanist Carl Linnaeus is regarded as the father of taxonomy, as he developed a system known as Linnaean classification for categorization of organisms and binomial nomenclature for naming organisms.

In biological classification, these taxa form a hierarchy. Each kind of organism is assigned to its own **species**, and similar species are grouped into a **genus** (plural: genera). Similar genera are grouped into a **family**, families into an **order**, orders into a **class**, classes into a **phylum** (plural: phyla), phyla into a **kingdom** and kingdoms into a **domain**. The domain is at the top of this hierarchical system.

Modern biologists classify organisms in eight different levels or groups as given blow:

1. Domain
2. Kingdom
3. Phylum
4. Class
5. Order
6. Family
7. Genus
8. Species

Mnemonic device to memorize taxonomic order

Dear King Phillip Came over from Great Spain (Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species)

The following table shows the classification of Gulaab, Cheetah and Man:

Organism	Gulaab	Cheetah	Human
Domain	Eukarya	Eukarya	Eukarya
Kingdom	Plantae	Animalia	Animalia
Phylum	Magnoliophyta	Chordata	Chordata
Class	Magnoliopsida	Mammalia	Mammalia
Order	Rosales	Carnivore	Primates
Family	Rosaceae	Felidae	Hominidae
Genus	Rosa	Pardus	Homo
Species	Indica	Pardus	Sapiens
Scientific Name	*Rosa indica*	*Pardus pardus*	*Homo sapiens*

Mnemonic device for man's taxonomic classification is: Eh, *All Cool Men Prefer Having Heavy Sideburns*. (**Eukarya**, **Chordata**, **Mammalia**, **Primatae**, **Hominidae**, **Homo**, **Sapiens**).

Binomial nomenclature is a formal system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms, although they can be based on words from other languages. Such a name is called a binomial name or a scientific name. The first part of the name identifies the genus to which the species belongs; the second part identifies the species within the genus. For example, humans belong to the genus Homo and within this genus to the species *Homo sapiens*. Scientific name must be *italicised* or underlined.

THREE DOMAINS

Biologists used to divide organisms into two large groupings prokaryotes and eukaryotes based on their cell structure. As you know that prokaryotes and eukaryotes have significantly different cellular structures. In the 1970s, prokaryotes were discovered living in extreme environments, such as hot springs where temperatures often exceed 100 °C. These extremophiles, as they are known, were not like typical bacteria. Studies revealed that the genes coding for the RNA that makes up their ribosomes were more like those of eukaryotes. They were found to share features with both typical bacteria and eukaryotes.

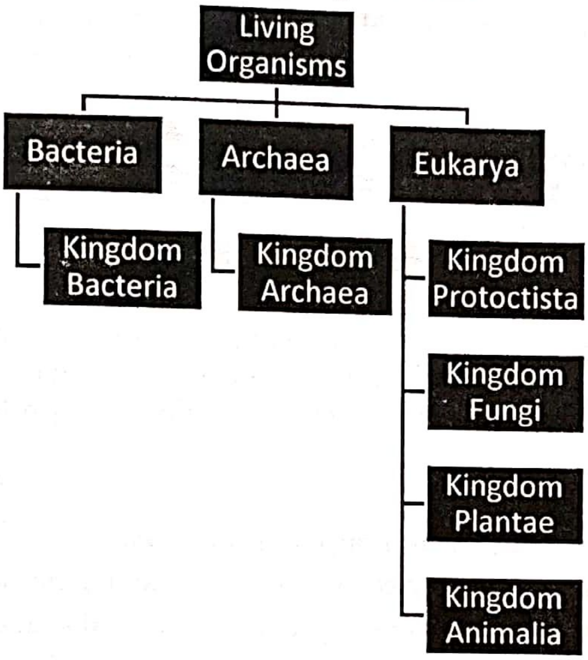
This meant that a new taxon, the domain, had to be introduced to reflect the differences between these extremophiles and typical bacteria. The domain is the taxon at the top of the hierarchy. The prokaryotes are divided between the domains Bacteria and Archaea and all the eukaryotes are placed into the domain Eukarya.

Domain Bacteria

Bacteria are prokaryotic as their cells have no nucleus. They are all small organisms that vary in size between that of the largest virus and the smallest single-celled eukaryote. The characteristic features of bacteria are:

- cells with no nucleus
- DNA exists as a circular 'chromosome' and does not have histone proteins associated with it

- smaller circular molecules of DNA called plasmids are often present
- no membrane-bound organelles (such as mitochondria, endoplasmic reticulum, Golgi body, chloroplasts) are present
- ribosomes (70 S) are smaller than in eukaryotic cells
- cell wall is always present and contains peptidoglycans (not cellulose)
- cells divide by binary fission, not by mitosis
- usually exist as single cells or small groups of cells.



Domain Archaea

Archaeans are also prokaryotic as their cells have no nucleus. Their range of size is similar to that of bacteria. Many inhabit extreme environments. The characteristic features of archaeans are:

- cells with no membrane-bound organelles
- DNA exists as a circular 'chromosome' and does have histone proteins associated with it
- smaller circular molecules of DNA called plasmids are often present
- ribosomes (70 S) are smaller than in eukaryotic cells, but they have features that are similar to those in eukaryotic ribosomes, not to bacterial ribosomes
- cell wall always present, but does not contain peptidoglycans
- cells divide by binary fission, not by mitosis
- usually exist as single cells or small groups of cells.

The metabolism of archaeans is similar to that of bacteria, but the way in which transcription occurs has much in common with eukaryotes.

Domain Eukarya

All the organisms classified into this domain have cells with nuclei and membrane-bound organelles. Their characteristic features are:

- cells with a nucleus and membrane-bound organelles
- DNA in the nucleus arranged as linear chromosomes with histone proteins
- ribosomes (80 S) in the cytosol are larger than in prokaryotes; chloroplasts and mitochondria have 70 S ribosomes, like those in prokaryotes.
- chloroplast and mitochondrial DNA is circular as in prokaryotes
- a great diversity of forms: there are unicellular, colonial and multicellular organisms
- cell division is by mitosis
- many different ways of reproducing – asexually and sexually.

The three domains are each divided into kingdoms. The following section describes the features of the four kingdoms of the Eukarya.

Kingdom Protoctista

The Protoctista is made up of a very diverse range of eukaryotic organisms, which includes those that are often called protozoans ('simple animals') and algae, such as seaweeds. Any eukaryote that is not a fungus, plant or animal is classified as a protoctist. The characteristic features of protoctists are:

- eukaryotic
- mostly single-celled, or exist as groups of similar cells
- some have animal-like cells (no cell wall) and are sometimes known as protozoa
- others have plant-like cells (with cellulose cell walls and chloroplasts) and are sometimes known as algae.

Many organisms in this kingdom may actually be more closely related to organisms in other kingdoms than they are to each other. For example, there are strong arguments for classifying algae as plants.

Kingdom Fungi

Fungi have some similarities with plants, but none of them is able to photosynthesise. They are all heterotrophic, obtaining energy and carbon from dead and decaying matter or by feeding as parasites on living organisms. There is a vast range in size from the microscopic yeasts to what may be the world's largest organism. Characteristic features of fungi are:

- eukaryotic
- do not have chlorophyll and do not photosynthesise
- heterotrophic nutrition – they use organic compounds made by other organisms as their source of energy and source of molecules for metabolism
- reproduce by means of spores
- simple body form, which may be unicellular or made up of long threads called hyphae
- cells have cell walls made of chitin or other substances, not cellulose
- never have cilia or flagella.

Kingdom Plantae

Plantae (plants) are all multicellular photosynthetic organisms. They have complex bodies that are often highly branched both above and below ground. Characteristic features of plants are:

- multicellular eukaryotes with cells that are differentiated to form tissues and organs
- few types of specialised cells
- some cells have chloroplasts and photosynthesise
- cells have large, often permanent vacuoles for support
- autotrophic nutrition
- cell walls are always present and are made of cellulose
- cells may occasionally have flagella – for example, male gametes in ferns.

Kingdom Animalia

The Animalia are multicellular organisms that are all heterotrophic with many ways of obtaining their food. There is a great diversity of forms within this kingdom. The nervous system is unique to the animal kingdom. Characteristic features of animals are:

- multicellular eukaryotes with many different types of specialised cells
- cells that are differentiated to form tissues and organs
- cells do not have chloroplasts and cannot photosynthesise
- cell vacuoles are small and temporary (for example, lysosomes and food vacuoles)
- heterotrophic nutrition
- cells do not have cell walls
- communication is by the nervous system
- cells sometimes have cilia or flagella.

CLASSIFICATION OF PLANTS

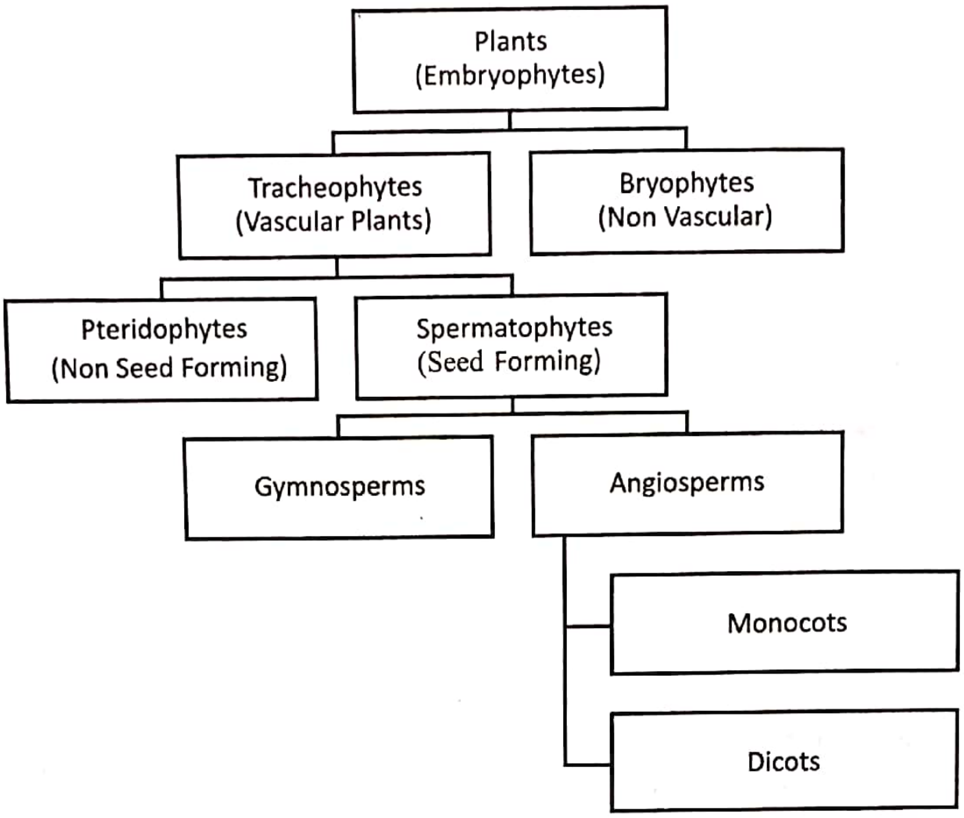
The kingdom Metaphyta or the plant kingdom in its true sense includes all the eukaryotic, multicellular, photosynthetic plants found in this biosphere. It consists of two major groups of plants bryophytes and tracheophytes. Both bryophytes and tracheophytes possess an embryo stage and hence, collectively described under **Embroyphyta**. Tracheophytes include the pteridophytes, gymnosperms and angiosperms.

Bryophytes (Mosses)

Bryophytes are a group of simple and primitive plants. In their level of organization, the bryophytes lie between the green algae and higher vascular plants. They do not have vascular tissues.

1. Bryophytes have body like a thallus, i.e. have no true roots, stem and leaves.
2. They grow in moist and shady places forming a dense mass or mat on damp soil, rock, logs and other substrata.
3. They are basically terrestrial forms, but require the presence of water for completing the life cycle. Hence, they are commonly described as 'amphibians of the plant kingdom'.
4. Bryophytes are nonvascular embryo-bearing plants.
5. Bryophytes are multicellular photosynthetic plants.

The division Bryophytes has been divided into three classes, namely: Hepaticae - Commonly called **Liverworts;** Anthocerotae - Commonly called **Hornworts** and Musci - Commonly called **Mosses.**



Tracheophytes (Vascular Plants)

Tracheophytes include the true land plants or vascular plants. The adult plant body is a sporophyte and shows definite root, stem and leaves. Vascular tissues xylem and phloem are present for the translocation of water and food, respectively. Tracheophytes include these major groups of plants, namely:

- **Pteridophytes:** Vascular plants which do not produce seeds.
- **Spermatophytes:** Vascular plants which produce seeds.

Pteridophytes (Non-seed Plants)

The division **Pteridophyta** includes a group of primitive vascular plants, commonly called pteridophytes or **Ferns.**

1. The adult plant body in these plants is a sporophyte.
2. Plant body shows differentiation into true roots, stem and leaves.
3. The stem is mostly herbaceous. Leaves may be smaller or larger.
4. Vascular tissues are present in all the vegetative parts of the plant body.
5. Pteridophytes have no flowers and do not produce seeds.

Spermatophytes (Seed-bearing Plants)

A large division (Spermatophyta) that comprises the plants bearing seeds, including the gymnosperms and angiosperms.

Gymnosperms (Naked-seed Plants)

Gymnosperm is common name for any *seed-bearing* vascular plant *without flowers*. There are several types: the cycad, ginkgo, conifer and yew.

Angiosperms (Flowering Plants)

Angiosperms represent the most advanced group of vascular plants. They are commonly called *'Flowering plants'*. They exceed all other major groups of living plants in number and diversity. Members of the group are the source of most of the food on which humans and other mammals rely and of many raw materials and natural products. Here is a comparison of Gymnosperms and Angiosperms.

Gymnosperms	Angiosperms
Gymnosperms are non-flowering plants.	Angiosperms are flowering plants.
Seeds are not enclosed inside fruits (naked).	Seeds are enclosed inside fruits.
Leaves are needle shaped.	Leaves are broad.
Mainly found in hilly areas and cold regions.	Almost found in every kind of environment.
Gymnosperms produce cones.	Angiosperms do not produce cones.
Gymnosperms produce softwood that is used to make furniture.	Angiosperms produce hardwood that is used to make furniture and agricultural implements.
Examples are conifers (chir, pinus, juniper, deodar, etc.).	Examples are all flowering and fruit-producing plants e.g. rose, mango, wheat, etc.

ANIMAL KINGDOM

The animal kingdom includes eukaryotic multicellular organisms which exhibit heterotrophic engestive nutrition. They are commonly known as animals and differ characteristically from the other major groups of plants, in their capacity to be able to move. Animals contribute to about a million living species that occur in all types of habitat. Animals exhibit a great deal of variation in their form, size and life-styles.

Animal Diversity

At present, there are 36 phylum of animal kingdom. And this number is swelling. However, there are nine major phyla as described below.

1. **Porifera** (sponges)
2. **Cnidaria/Coelentrata** (jellyfish, hydras, sea anemones and corals)
3. **Platyhelminthes** (flatworms including planaria, flukes and tapeworms)
4. **Nematoda** (roundworms)
5. **Mollusca** (molluscs including bivalves, snails and slugs and octopuses and squids)
6. **Annelida** (segmented worms including earthworms, leeches, etc)
7. **Echinodermata** (sea stars, sea cucumbers and sea urchins)
8. **Arthropods** (arachnids, crustaceans, millipedes, centipedes and insects)
9. **Chordata** (animals with notochords, this group includes the vertebrates)

VERTEBRATES AND INVERTEBRATES

Almost all animals discussed above fall into one of two groups or categories, namely vertebrates and invertebrates. Vertebrates have a spinal column, or backbone, running the length of the body which the invertebrates do not. Vertebrates are often larger and have more complex bodies than invertebrates. However, there are many more invertebrates than vertebrates. A comparison of vertebrates and invertebrates is as under:

Invertebrate	Vertebrate
Animals without a backbone or vertebral column are called invertebrates.	Animals with vertebral column are called vertebrates.
Example are insects, flatworms, etc.	Examples are parrots, humans, snakes etc.
Invertebrates have less-developed internal skeleton and brain.	Vertebrates have well-developed internal skeleton and highly-developed brain.
According to the latest research, these are classified into 36 phyla.	Vertebrates are classified under chordates and divided into five classes: fish, amphibians, reptiles, birds and mammals.
Invertebrates are larger in number.	Vertebrates are smaller in number as compared to invertebrates.
Invertebrates are slow-moving organisms.	Vertebrates are fast moving organisms.

Vertebrates are classified into Chordata includes following classes i.e. pisces, amphibians, reptiles, birds and mammals.

Fish (Pisces)

Fish is a diverse group of animals that live and breathe in water. All fish are vertebrates with gills for breathing. Most fish have fins for swimming, scales for protection and a streamlined body for moving easily through the water. Examples are rahu, thala, trout, tuna and shark.

Note: *Following animals don't belong to fish: Jelly fish, star fish, and silver fish. These are invertebrates.*

Amphibians

Amphibians are animals with moist, hairless skin through which water can pass in and out. Nearly all amphibians live the first part of their lives in water and the second part on land therefore called *amphibian*, which comes from the Greek words *amphi*, meaning "both," and *bios*, meaning "life." Amphibians cannot reproduce without water. They were the first animals with backbones to adapt life on land. They are the ancestors of reptiles, which in turn gave rise to mammals and birds. These include frog, toad, Salamanders and newts.

Cold-blooded and warm-blooded Animals

The cold-blooded animal has the same temperature as the air or water around it. Their body temperature is not constant. A cold-blooded animal has to stay in the sun to get warm. It must find shade to cool off. Reptiles, amphibians and fish are cold-blooded / ectotherms.

The warm-blooded animal stays about the same temperature all the time. Warm-blooded animals use food energy to stay warm. Some warm-blooded animals can sweat to cool off. Birds and mammals are warm-blooded / endotherms.

Reptiles

Reptiles display a unique combination of characteristics that distinguishes them from other vertebrates. Like amphibians, modern reptiles are cold-blooded, or ectothermic. Like birds, most reptiles hatch from eggs that are laid on land, covered by a protective shell. Reptiles breathe air with lungs, as do most mature amphibians and all birds and mammals. And like amphibians and mammals, most reptiles, with the exception of turtles, have teeth. Reptile skin is tough, dry and have horny scales. Examples are alligator, snake, lizard, tortoise, turtles, skink, geckos, pythons and crocodile.

Birds (Aves)

Birds are vertebrates, which possess feathers and have no teeth in their jaws. Many characteristics and behaviours of birds are distinct from all other animals, but there are some similarities. Like mammals, birds have four-chambered hearts and are warm-blooded. Like reptiles, birds develop from embryos in eggs outside the mother's body.

Mammals

Mammals include organisms that raise their young ones on milk. Most mammals are covered with hair or fur, and most have specialized teeth that help them to cut or chew their food. Compared to other vertebrates, mammals have highly-developed nervous systems, and they show an intelligence and resourcefulness that few other animals can match. Mammals include some of the most familiar members of the animal kingdom, such as cats, dogs, bats, elephants and whales.

Here is a comparison chart of vertebrates.

Characteristics	Pisces	Amphibian	Reptilian	Aves	Mammalian
Habitat	Aquatic	Amphibious	Terrestrial/Aquatic	Terrestrial	Terrestrial
Exoskeleton	Scales (dermal)	Usually absent	Scales (epidermal)	Feathers	Hair
Respiratory Organs	Gills	Lungs (gills at birth)	Lungs	Lungs	Lungs
Locomotive Organs	Fins	Limbs	Limbs	Limbs/ feathers	Limbs
Heart	Two chambers	Three chambers	Three chambers	Four chambers	Four chambers
Mode of Reproduction	Oviparous	Oviparous	Oviparous/viviparous	Oviparous	Mostly Viviparous
Fertilization	External	External	Internal	Internal	Internal
Cold/warm-blooded	Cold-blooded	Cold-blooded	Cold-blooded	Warm-blooded	Warm-blooded
Example	Shark	Frog	Snake	Eagle	Tiger

- **Viviparous:** Producing living young's instead of eggs.
- **Oviparous:** Producing eggs that develop and hatch outside the maternal body.

- **Oviviviparous:** Producing eggs that develop within the maternal body (as of various fishes or reptiles) and hatch within or immediately after release from the parent.

Important Animals and their Natural Locations (Habitat)

	Name of Animal	Location
1.	Ostrich (Flightless Bird)	Africa
2.	Penguin (Flightless Bird)	Southern Hemisphere / Antarctica
3.	Kiwi (Flightless Bird)	New Zealand
4.	Rhea (Flightless Bird)	South America
5.	Emu (Flightless Bird)	Australia
6.	Rahu, Thalla and Trout (Fish)	Fresh Water all over the globe
7.	Tuna and Shark (Fish)	Marine Water Fish
8.	Panda (Mammal)	China
9.	Blind Dolphin (Mammal)	Indus River
10.	Kangaroo (Mammal)	Australia
11.	Yak (Mammal)	Himalayan Region and Tibet (China)
12.	Llama (Mammal)	South America
13.	Alligator (Reptile)	America and China
14.	Rattle Snake (Reptile)	America
15.	Duck Bill Platypus (Egg-laying Mammal)	Australia and Tasmania
16.	Spiny Ant Eater (Egg-laying Mammal)	Australia and New Guinea
17.	Opossum (Pouched Mammal)	America
18.	Koala (Mammal)	Tasmania
19.	Pangolin (Mammal)	Africa and Asia
20.	Rhinoceros (Mammal)	Africa and Asia
21.	Elephant (Mammal)	Africa and Asia
22.	Polar Bear (Mammal)	Arctic Circle
23.	Snow Leopard (Mammal)	Asia (Pakistan and Afghanistan)
24.	Flamingo (Wading Bird)	America
25.	Blue Marlin (Fish)	Indo Pacific Region
26.	Zebra (Mammal)	Africa
27.	Jaguar (Big Cat, Mammal)	South America
28.	King Cobra (Reptile)	South Asia, Indonesia and Philippines
29.	Moose (Eurasian Elk, Mammal)	Eurasia, America
30.	Elk (Deer, Mammal)	North America, Eastern Asia

CLASSIFICATION OF LIVING THINGS (MCQS)

Note: **Answers are Bold and Underlined.**

1. **Identify from the following, the only taxonomic category that has a real existence.**

(a) Phylum **(b) Species** (c) Genus (d) Kingdom

2. **In angiosperm, characters of flowers are used in classification because**

(a) Flowers are attractive

(b) Flowers are large

(c) Characters of flowers are conservative

(d) None of the above

3. **Practical purpose of taxonomy or classification is to**

(a) Know the evolutionary history

(b) Explain the origin of organisms

(c) Facilitate the identification of unknown species

(d) Identification of medicinal plants

4. **Two plants can be conclusively said to belong to the same species if they**

(a) Have more than 90 percent similar genes

(b) Can reproduce freely with each other and form seeds

(c) Have same number of chromosomes

(d) Look similar and possess identical secondary metabolites

5. **One of the most important functions of botanical gardens is that**

(a) One can observe tropical plants there

(b) They provide the natural habitat for wild life

(c) They allow ex-situ conservation of germplasm

(d) They provide a beautiful area for recreation

6. **Which one of the following statements is incorrect?**

(a) Viviparity is the reproductive pattern shown by most mammals

(b) Viviparity occurs primarily in salamanders and caecilians.

(c) In viviparity, a shell does not form around the egg.

(d) Viviparity is not found in species of lizards and snakes

7. **Which one of the following characteristics is NOT a shared by birds and mammals?**

(a) A backbone and internal skeleton (b) Breathing using lungs

(c) Viviparity (d) Warm blooded nature

8. **Animals having a built in thermostat to maintain constant body temperature called**

(a) Biothermic (b) Poikilothermic

(c) Oligothermic **(d) Homeothermic**

9. **Single-celled eukaryotes are included in**
(a) Fungi
(b) Protista
(c) Monera
(d) Archaea

10. **Arrange the following in the ascending order of Linnaean hierarchy**
(a) Domain-Kingdom – Phylum – Class – Order – Family – Genus – Species
(b) Kingdom – Family – Genus – Species – Class – Phylum – Order- Domain
(c) Kingdom – Order – Species – Genus – Class – Family – Domain- Phylum
(d) Domain- Species – Genus – Family – Order – Class – Phylum – Kingdom

11. **Taxonomic hierarchy refers to**
(a) A list of botanists or zoologists who have worked on taxonomy of a species or group
(b) A group of senior taxonomists who decide the nomenclature of plants and animals
(c) Step-wise arrangement of all categories for classification of plants and animals
(d) Classification of a species based on fossil record

12. **Which type of DNA is found in bacteria?**
(a) Helical DNA
(b) Membrane bound DNA
(c) Straight DNA
(d) Circular free DNA

13. **Plasmids are most often found in**
(a) Virus
(b) Bacteria
(c) Fungi
(d) Viroid

14. **Gymnosperms produce neither flower nor fruit because they do not possess**
(a) Embryo
(b) Ovary
(c) Ovule
(d) Seed

15. **Gymnosperms are**
(a) Flowering plants
(b) Seed bearing plants
(c) Seedless flowering plants
(d) Fruit bearing seed plants

16. **Nonvascular plants are called**
(a) Bryophytes
(b) Fungi
(c) Algae
(d) Gymnosperms

17. **Which of the following plant group produces spores and embryo but lacks vascular tissue and seeds?**
(a) Bryophyta
(b) Rhodophyta
(c) Pteridophyta
(d) Phaeophyta

18. **Viruses are denied a kingdom of their own because**
(a) They are too poorly understood
(b) They are too small
(c) Their genetics cannot be determined
(d) They are not organisms

19. **True multicellularity occurs only in**
(a) Animals
(b) Eukaryotes
(c) Plants and animals
(d) Plants, animals and fungi

20. **A related group of genera comprise**

(a) An order (b) **A family** (c) A class (d) A phylum

21. **Prokaryotic organisms make up the**

(a) Archaebacteria, Eubacteria, and Protists

(b) Archaebacteria and Protists

(c) Protists and Eubacteria

(d) **Eubacteria and Archaebacteria**

22. **In the current taxonomic system, families are grouped into**

(a) Classes (b) Phyla (c) **Orders** (d) Divisions

23. **Of the six kingdoms now recognized,**

(a) Two are plants and four are animals

(b) **Four are eukaryotes and two are prokaryotes**

(c) Four are macroscopic and two are microscopic

(d) Two are eukaryotes and four are prokaryotes

24. **Throughout the world, official species names are in**

(a) **Latin** (b) Greek (c) English (d) French

25. **The classification level in which classes with similar characteristics are grouped are called a (n):**

(a) Class (b) Order (c) **Phylum** (d) Taxonomy

26. **The evolutionary history of a species is its:**

(a) **Phylogeny** (b) History

(c) Make-up (d) Scientific Name

27. **The most general level of classification for an organism is called:**

(a) **Domain** (b) Kingdom (c) Class (d) Family

28. **____ is an organism that is made up of cell that lacks a true nucleus.**

(a) Eukaryotes (b) **Prokaryotes** (c) Kingdoms (d) Cells

29. **The two word naming system for organisms is called:**

(a) Archaea (b) Taxonomy

(c) Kingdoms (d) **Binomial Nomenclature**

30. **Name of the scientist who developed a method of grouping organisms based on physical and structural similarities is?**

(a) Richard Holt (b) Aristotle

(c) Gregor Mendel (d) **Carolus Linnaeus**

CHAPTER 11

HUMAN PHYSIOLOGY

Human physiology is the scientific study of various functions of the human body in its normal state. These functions could be mechanical or biochemical in nature. Along with anatomy, human physiology is one of the basic sciences in the medical field with its application throughout the medical care.

Facts about Human Body

Largest organ of the body	Skin
Largest internal organ	Liver
Total No. of muscles	630+
Longest bone	Femur
Smallest bone	Stapes/Stirrup
Hardest bone	Teeth (Enamel)
Smallest muscle	Stapes muscle
Largest muscle (Bulkiest)	Gluteus Maximus
Total No. of bones	206
Total No. of vertebrae	33
Normal body temperature	37° C
Normal heartbeat	72 per minute
Normal respiratory rate	16 - 20 per minute
Normal blood pressure	120/80 mmHg
Strongest muscle	Masseter (Jaw), Uterus
Largest element (amount)	Oxygen
Water % of body	65-75%
Spinal nerves	31 pairs
Volume of blood	5-6 litres
Most common blood type	O^+ and A^+
Least common blood type	AB^-
Largest part of brain	Cerebrum
Dual Gland	Pancreas
Largest cell	Nerve cell
Gestation period	267 days
Largest artery	Aorta (2.5 cm)
Largest vein	Inferior vena cava
Longest muscle	Sartorius
Length of small intestine	25 ft (7.62m)
pH of blood	7.3-7.4

Human Physiology: Major Systems

Although various different human organ systems are often studied as separate entities, in reality, they all interact with each other and work together to keep the human body functioning. Following are the major systems of the body:

- Circulatory System
- Respiratory System
- Digestive System
- Urinary/Renal System
- Immune System
- Nervous System
- Musculoskeletal System
- Reproductive System

CIRCULATORY SYSTEM

The circulatory system is made up of the vessels and the muscles that help and control the flow of the blood around the body. This process is called circulation. The main parts of the system are the *heart and blood vessels.*

Human Heart

Human heart is a fist-sized, muscular organ that pumps blood through the body. Everyday, the heart pumps about 2,000 gallons (7,600 litres) of blood, beating about 100,000 times. The human heart has four chambers. The upper two chambers, the right and left atria, are receiving chambers for blood. The atria are sometimes known as **auricles**. They collect blood that pours in from veins, blood vessels that return blood to the heart. The heart's lower two chambers, the right and left **ventricles**, are the powerful pumping chambers. The ventricles propel blood into arteries, blood vessels that carry blood away from the heart. A wall of tissues (septum) separates the right and left sides of the heart. Each side pumps blood through a different circuit of blood vessels: the right side of the heart pumps oxygen-poor blood to the lungs, while the left side of the heart pumps oxygen-rich blood to the body.

Four valves within the heart prevent blood from flowing backward in the heart. The valves open easily in the direction of blood flow, but when blood pushes against the valves in the opposite direction, the valves close. Two valves, known as atrio-ventricular valves, are located between the atria and ventricles.

- The right atrio-ventricular valve is formed from three flaps of tissues and is called **the tricuspid valve.**
- The left atrio-ventricular valve has two flaps and is called the **bicuspid** or **mitral valve.**

The other two heart valves are located between the ventricles and arteries. They are called semi-lunar valves because they each consist of three half-moon-shaped flaps of tissues.

- The right semi-lunar valve, between the right ventricle and pulmonary artery, is also called the **pulmonary valve.**
- The left semi-lunar valve, between the left ventricle and aorta, is also called the **aortic valve.**

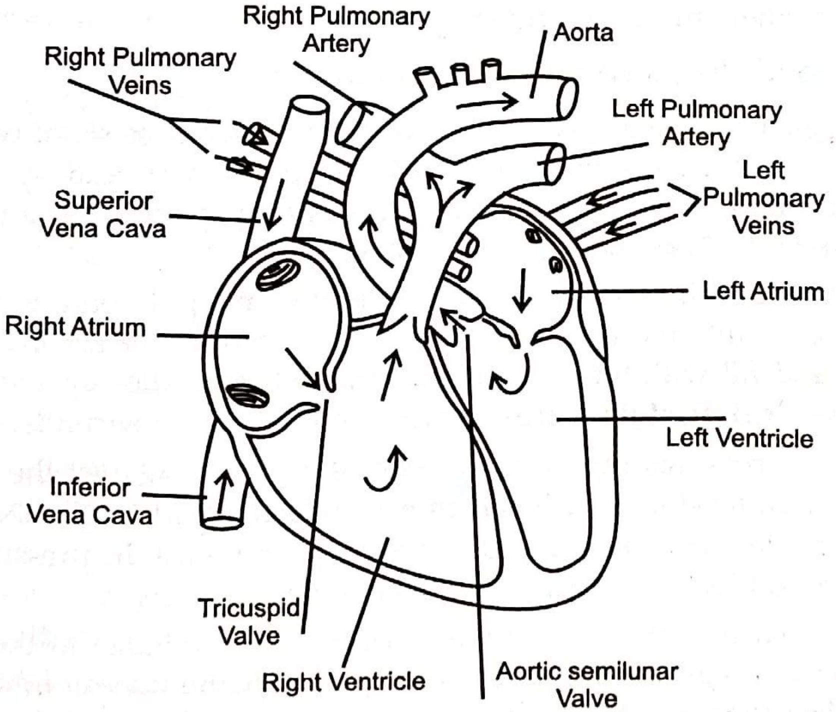


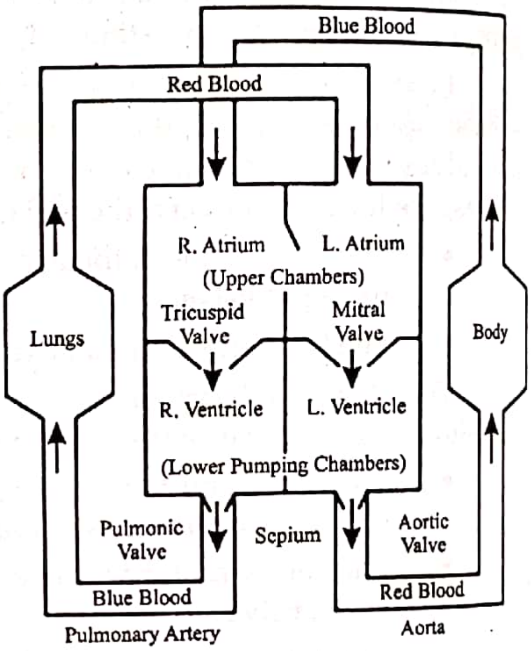
Figure: Human Heart

Blood circulation: How does blood circulate in the body?

Blood returning from a trip around the body has given up most of its oxygen and picked up carbon dioxide from the body's tissues. This oxygen-poor blood feeds into two large veins, the superior vena cava and inferior vena cava, which empty into the right atrium of the heart. The right atrium conducts blood to the right ventricle, and the right ventricle pumps blood into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it picks up a fresh supply of oxygen and eliminates carbon dioxide. Now oxygen rich blood returns to the heart through the pulmonary veins, which empty into the left atrium. Blood passes from the left atrium into the left ventricle, from where it is pumped out of the heart into the aorta, the body's largest artery. Smaller arteries that branch off the aorta distribute blood to the whole body.

The above described circulation can be divided into two circuits. In each circuit, the blood returns to the heart. These two circuits are:

- **Systemic circulation:** This circuit takes oxygenated blood from the left side of the heart to the body. When the blood returns to the right side of the heart, it is deoxygenated, as the oxygen has been mostly used by the muscles and organs in order to make energy.
- **Pulmonary circulation:** This circuit takes deoxygenated blood from the right side of the heart to the lungs where it is oxygenated. It then returns this newly-oxygenated blood to the left side of the heart where the cycle begins again.



Normal Blood Circulation

Cardiac Cycle, Blood Pressure and Heart beat

One complete heartbeat makes up a cardiac cycle, which consists of two phases. In the first phase, the ventricles contract sending blood into the pulmonary and systemic circulation. To prevent the flow of blood backwards into the atria during systole, the atrio-ventricular valves close, creating the first (*"lub"*) sound. This is called **systole.**

When the ventricles finish contracting, the aortic and pulmonic valves close to prevent blood from flowing back into the ventricles. This is what creates the second sound (*"dub"*). Then, the ventricles relax and fill with blood from the atria, which makes up the second phase of the cardiac cycle. This is called **diastole.** Cardiac cycle completes in 0.8 seconds.

Blood pressure represents the pressure exerted by blood against the arterial walls during heart muscle contraction (systole) and heart muscle relaxation (diastole). Normal systolic blood pressure in an adult varies between 110 and 140 mmHg, and diastolic pressure varies between 60 and 90 mmHg. Standard blood pressure is 120/80 mmHg.

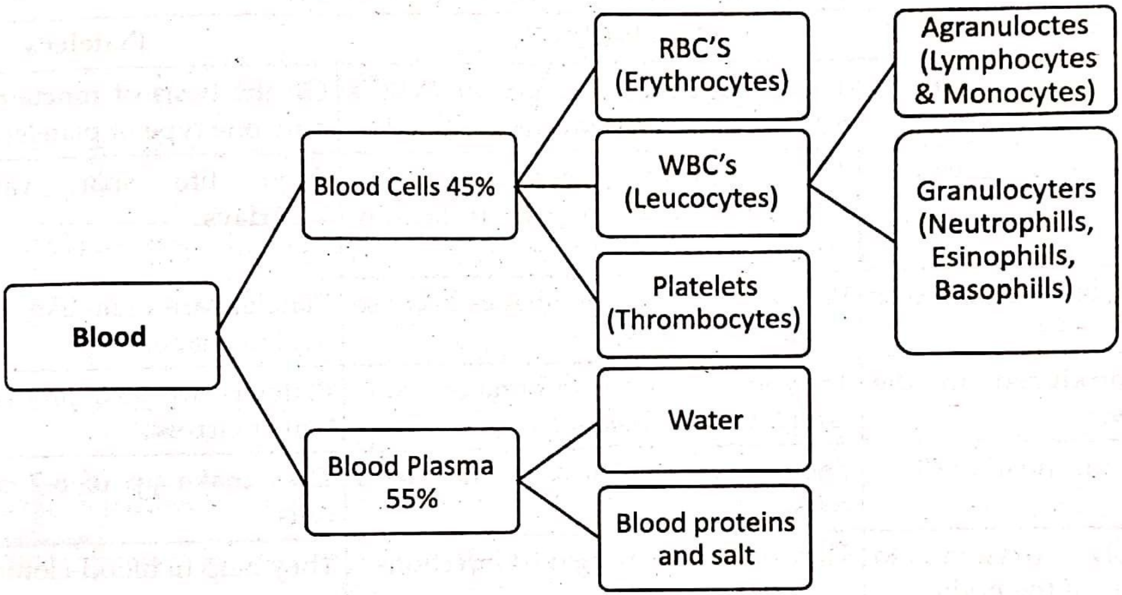
The blood from each contraction of the heart produces a bulge in the artery. We call that bulge a *pulse*. One pulse equals one *heartbeat*. Heart rate is the number of times the heart beats per minute. The resting heart rate for the average person is between 70 and 90 beats per minute (bpm).

The term **tachycardia** is applied to a rapid heart rate (over 100 bpm) and the term **bradycardia** indicates a slow heart rate (less than 50 bpm). Standard heart rate is 72 beats per minute.

HUMAN BLOOD

The volume of blood in the body is about six litres and its 7 to 8 % of human body weight. About 55 % of the blood is composed of a liquid known as *plasma*. The rest of the blood is made up of three major types of cells: *red blood cells, white blood cells, and platelets.* Blood is slightly alkaline, with a pH between 7.35 and 7.45.

Blood Plasma is the liquid portion of the blood. Plasma which is 92 % water also contains *albumin, fibrinogen, globulins,* and other clotting proteins. Plasma serves a variety of functions, from maintaining a satisfactory blood pressure and volume to supplying critical proteins for blood-clotting and immunity.



Blood Serum is clear, yellowish fluid that remains as the liquid portion of blood after clotting has taken place. Before clotting occurs, the liquid of the blood is called plasma.

Functions of Blood

1. Blood carries oxygen from the lungs to all the other tissues in the body and, in turn, carries waste products, predominantly carbon dioxide, back to the lungs where they are released into the air.
2. Food that has been processed by the digestive system into smaller components, such as proteins, fats, and carbohydrates, is also delivered to the tissues by the blood.
3. Waste products, produced during metabolism, are carried by the blood to the kidneys, where they are transferred from the blood into urine and eliminated from the body.
4. In addition to oxygen and nutrients, blood also transports special chemicals, called hormones that regulate certain body functions.
5. The blood is responsible for the activities of the immune system; it helps to fight infections and disease.
6. In addition, blood carries blood-clotting factors that help in blood clotting after injury.

7. Blood is vital to maintaining a stable body temperature; in humans, body temperature normally fluctuates within a degree of 37.0° C (98.6° F).
8. Blood keeps the tissues wet and supplies moisture to the tissue that is necessary for survival.

Blood Cells

A blood cell, also called a **haematocyte,** is a cell produced by haematopoiesis and normally found in blood. In mammals, these fall into three general categories:

- Red blood cells — Erythrocytes
- White blood cells — Leukocytes
- Platelets — Thrombocytes.

Together, these three kinds of blood cells add up to a total 45 % of the blood tissue by volume. Here is the comparison of different blood cells in the body.

RBC's	WBC's	Platelet's
There is only one type of RBCs found in the blood.	There are different types of WBC's with distinct functions in the blood.	On the basis of function, there are only one type of platelets.
Their life span is 120 days.	They have a life of few days but can live several days to years in healthy body.	Their life span varies from 7-10 days.
RBCs are biconcave disc shaped.	WBCs have different shapes because of different types.	Platelets are plate-like, spherical or oval in shape.
They are produced in the bone marrow.	They are produced in bone marrow, lymph nodes, spleen, etc.	Platelets are also produced in the bone marrow.
They make up nearly 93 % blood cells.	They make up 0.16% of the blood cells.	They make up of 6-7 % of blood cells.
They supply oxygen to different parts of the body.	They defend body against infections.	They help in blood-clotting.
They are 4.5 million - 5.5 million per micro litre of blood.	There are 5000-7000 per micro litre of blood and can be up to 11000 per micro litre of blood.	There are 150,000 - 350,000 per micro litre of blood.
RBCs have no nucleus.	WBCs have nucleus.	Platelets have no nucleus.

VASCULAR SYSTEM (THE BLOOD VESSELS)

Arteries, veins, and capillaries comprise the vascular system. *Arteries* are strong and elastic vessels adapted for carrying blood away from the heart at relatively high pumping pressure. Arteries divide into progressively thinner tubes and eventually become fine branches called *arterioles.* The arterioles branch into the microscopic *capillaries.* Capillaries are the points of exchange between the blood and surrounding tissues. Materials cross in and out of the capillaries by passing through or between the cells that line the capillary. Blood leaving the capillaries, flows into a series of progressively larger vessels, called *venules,* which in turn unite to form *veins.* Veins are responsible for returning blood to the heart.

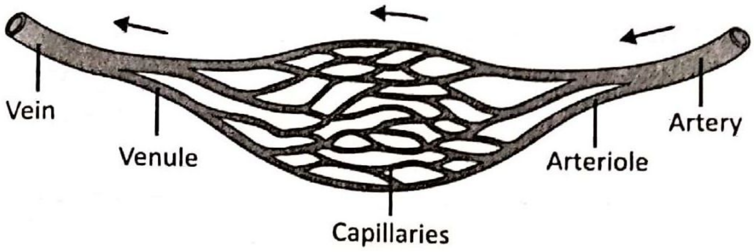


Figure: Blood Vessels

Comparison of Arteries, Veins and Capillaries

Arteries	Veins	Capillaries
Arteries are blood vessels that carry blood away from the heart.	Veins are blood vessels that carry blood towards the heart.	Capillaries distribute blood to the cells and tissues.
Arteries carry oxygenated blood with the exception of the pulmonary artery.	Veins carry deoxygenated blood with the exception of pulmonary veins.	These carry both oxygenated and deoxygenated blood.
No exchange of materials occurs in arteries.	No exchange of materials occurs in veins.	Exchange of materials occurs through capillaries.
Arteries have small bore.	Veins have larger bore than arteries.	Capillaries have one celled thick bore.
These have high blood pressure.	These have low blood pressure.	No pressure or failing pressure in capillaries.
There are no valves except at the base of pulmonary trunk and aorta.	Veins have valves. These valves prevent the backflow of the blood.	There are no valves in capillaries.
Arteries are thick and elastic.	Veins are thin and less elastic.	Capillaries have no muscle or elastic fibres.
Blood pressure, heartbeat or pulse can be detected.	No pulse in veins.	No pulse in capillaries.

LYMPHATIC SYSTEM

Lymph is diluted blood plasma containing large number of white blood cells, especially lymphocytes, and occasionally a few red blood cells. Because of the number of living cells it contains, lymph is classified as a *tissue fluid*. This fluid surrounds the tissues, bathe and lubricate them. **Lymphatic System** composed of circulatory vessels or ducts in which the fluid bathing the tissue cells of vertebrates is collected and carried to join the bloodstream.

The lymphatic system is of primary importance in transporting digested fat from the intestine to the bloodstream; in removing and destroying toxic substances; and in resisting the spread of disease throughout the body. The portions of the lymphatic system that collect the tissue fluids are known as lymphatic capillaries and are similar in structure to ordinary capillaries. The lymphatic capillaries that pick up digested fat in the villi of the intestine are known as *lacteals*. The lymphatic capillaries are more permeable than ordinary capillaries and allow passage of larger particles than would ordinarily pass through capillary walls; large-molecule proteins, produced as a result of tissue breakdown, pass into the lymphatics for transport away from the tissues.

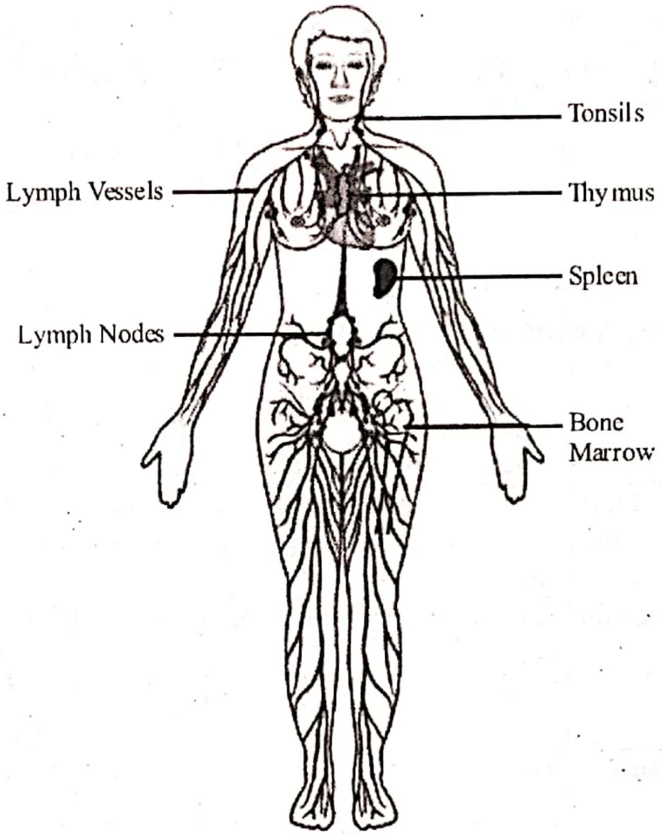


Figure: Lymphatic System

Along the course of the lymphatic vessels are situated the **lymph nodes,** more commonly called the lymph glands. These nodes are bean-shaped organs containing large numbers of leukocytes, embedded in a network of connective tissues. All the lymph being returned along the lymphatics to the bloodstream must pass through several of these nodes, which filter out infectious and toxic material and destroy it. The nodes serve as a centre for the production of phagocytes, which engulf bacteria and poisonous substances.

HUMAN COORDINATION SYSTEM

Most animals and plants are complex organisms, made up of many millions of cells. Different parts of the organism perform different functions. It is essential that information can pass between these different parts, so that their activities are coordinated. In animals, including mammals, there are two types of information transfer that are used to coordinate the body's activities:

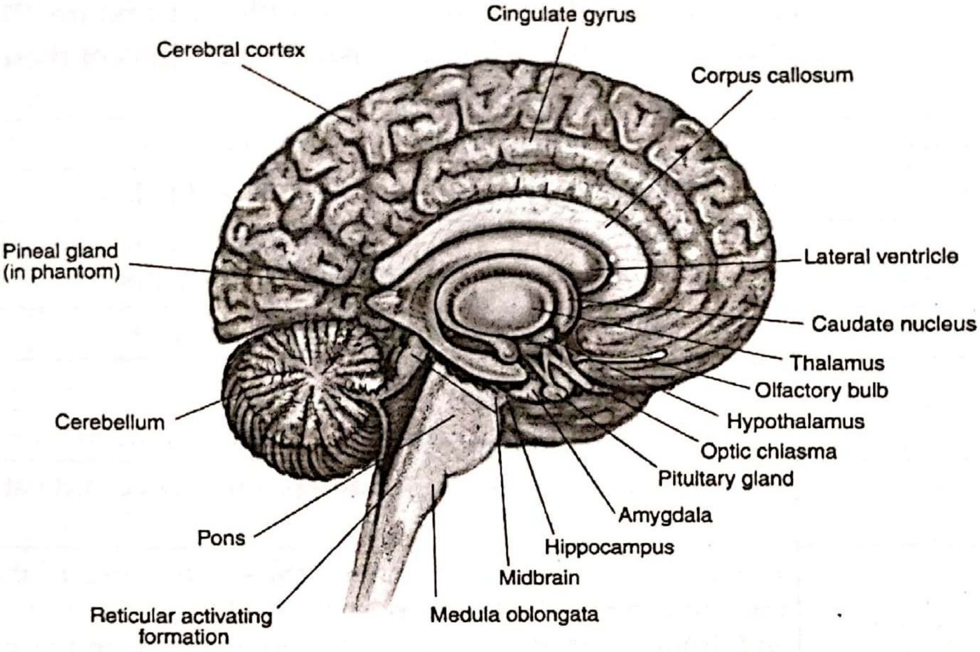
- nerves that transmit information in the form of electrical impulses
- chemical messengers called hormones that travel in the blood.

The mammalian nervous system is made up of the brain and spinal cord, which form the central nervous system (CNS), and the cranial and spinal nerves, which form the peripheral nervous system (PNS). Cranial nerves are attached to the brain and spinal nerves to the spinal cord. The nervous system is our body's decision and communication center.

The **central nervous system** (CNS) is the processing center for the nervous system. It receives information from and sends information to the peripheral nervous system. Both the brain and spinal cord are protected by three layers of connective tissue called the meninges.

The brain is made of three main parts: the **forebrain, midbrain**, and **hindbrain**. The forebrain consists of the *cerebrum, thalamus*, and *hypothalamus* (part of the limbic system). The midbrain consists of the *tectum* and *tegmentum*. The hindbrain is made of the *cerebellum, pons* and *medulla*. Often the midbrain, pons, and medulla are referred together as the **brainstem**.

The Cerebrum: The cerebrum or cortex is the largest part of the human brain, associated with higher brain function such as thought and action. The cerebral cortex is divided into four sections, called "lobes": the frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Here is a visual representation of the cortex:



What do each of these lobes do?

- **Frontal Lobe-** associated with reasoning, planning, speech, movement, emotions, and problem solving
- **Parietal Lobe-** associated with movement, orientation, recognition, perception of stimuli
- **Occipital Lobe-** associated with visual processing
- **Temporal Lobe-** associated with perception and recognition of auditory stimuli, memory, and speech

The cerebral cortex is highly wrinkled. Essentially this makes the brain more efficient, because it can increase the surface area of the brain and the amount of neurons within it. A deep furrow divides the cerebrum into two halves, known as the left and right hemispheres. The two hemispheres look mostly symmetrical yet it has been shown that each side functions slightly different than the other. Sometimes the right hemisphere is associated with creativity and the left hemispheres is associated with logic abilities. The **corpus callosum** is a bundle of axons which connects these two hemispheres.

The Cerebellum: The cerebellum, or "little brain", is similar to the cerebrum in that it has two hemispheres and has a highly folded surface or cortex. This structure is associated with regulation and coordination of movement, posture, and balance.

The cerebellum is assumed to be much older than the cerebrum, evolutionarily. In other words, animals which scientists assume to have evolved prior to humans, for example reptiles, do have developed cerebellums.

Limbic System: The limbic system, often referred to as the "emotional brain", is found buried within the cerebrum. Like the cerebellum, evolutionarily the structure is rather old. This system contains the *thalamus, hypothalamus, amygdala, and hippocampus.*

Brain Stem: Underneath the limbic system is the brain stem. This structure is responsible for basic vital life functions such as breathing, heartbeat, and blood pressure. The brain stem is made of the *midbrain, pons, and medulla.* Table below summarize functions of these structures.

Part of Nervous System	Function
Thalamus	Receive messages from five senses and send to limbic system.
Hypothalamus	Control pulse, thirst, appetite, sleep patterns etc also called pleasure and thirst centre. It also controls hormone production.
Amygdala	Controls fear and anger, pleasure & punishment.
Hippocampus	Controls long term memory.
Midbrain	Master coordinator and acts as a bridge also called relay centre.
Cerebellum	Control balance, movement, bodily posture and coordination among body parts.
Pons	The pons has two over-arching roles. The first is the regulation of breathing. Secondly, the pons is involved in the transmission of signals to and from other structures in the brain, such as the cerebrum or the cerebellum.
Medulla	Its functions are involuntary. It performs various tasks including regulating blood pressure and breathing.

Spinal Cord

The spinal cord is a long bundle of nerve tissues about 18 inches long and ¾ inch thick. It extends from the lower part of the brain down through spine. Along the way, various nerves branch out to the entire body. These are called the peripheral nervous system. The spinal cord is surrounded by a clear fluid called Cerebral Spinal Fluid (CSF) that acts as a cushion to protect the delicate nerve tissues against pressure and injury. There are 31 pairs of spinal nerves that run through vertebral column.

Peripheral Nervous System

There are two nervous systems in the human body and they relate to each other. The first is the central nervous system, which includes the brain and the spinal cord. The second nervous system, known as the peripheral nervous system, contains all the nerves in the body that lie outside of the spinal cord and brain. These two systems communicate with each other to make sure our body parts, such as our fingers, can send signals to the central nervous system for processing in our brains.

The peripheral nervous system consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves. Some of those nerve pairs are exclusively sensory cells, such as cells that detect information like smell and vision. Others are exclusively motor cells, like the eyeballs and hearing. Also, there are nerve pairs that have both sensory and motor cells, such as those involved in taste and some aspects of swallowing.

Sensory cells carry messages to the central nervous system. **Motor cells** carry the signal from the central nervous system to the internal organs, muscles, and glands in the periphery or the outer edges of the body. Both types of cells travel together to the spinal cord, but then they separate into two areas. One area is called the posterior sensory root, and the other is called the anterior sensory root.

The motor nerve cells are either somatic or autonomic. The **somatic** nerve cells carry messages from the outer areas of the body having to do with the senses. It is like a passageway from the environment to the central nervous system. That seems simple compared to the **autonomic** cells because the autonomic nerve cells are divided into three separate divisions called the parasympathetic, the sympathetic, and the enteric divisions.

These divisions are named by the functions that they are involved in throughout the body. The **parasympathetic division** is involved with slowing body functions, while the **sympathetic** division increases body functions. The **enteric division** is involved with all the functions in the gastrointestinal areas, such as the pancreas and gallbladder.

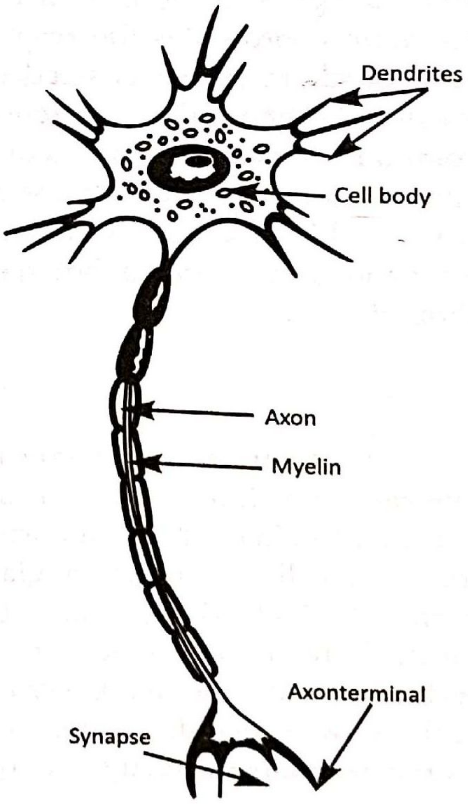
The parasympathetic division controls various functions which include inhibiting heart rate, constricting pupils, and contracting the bladder. The nerves of the sympathetic division often have an opposite effect when they are located within the same organs as parasympathetic nerves. Nerves of the sympathetic division speed up heart rate, dilate pupils, and relax the bladder. The sympathetic system is also involved in the flight or fight response. This is a response to potential danger that results in accelerated heart rate and an increase in metabolic rate.

NEURON

Brain is made of approximately 100 billion nerve cells called neurons. Neurons have the amazing ability to gather and transmit electrochemical signals at the speed of 200 mph. Neurons have three basic parts: Cell body, axon and dendrites.

Cell Body or Soma: This main part has all the necessary components of the cell, such as the nucleus, endoplasmic reticulum ribosomes and mitochondria. If the cell body dies, the neuron dies.

Axon: This long cable-like projection of the cell carries the electrochemical message (along the length of the cell). Depending upon the type of neuron, axons can be covered with a thin layer of myelin sheath, like an insulated electrical wire.



Myelin is made of fat and protein, and it helps to speed transmission of a nerve impulse down a long axon.

Dendrites or Nerve Endings: These small branch-like projections of the cell make connections to other cells and allow the neuron to talk with other cells or perceive the environment. Dendrites can be located on one or both ends of a cell.

Neurons come in many sizes. For example, a single sensory neuron from fingertip has an axon that extends the length of arm, while neurons within the brain may extend only a few millimetres. They also have different shapes depending on their functions. Neurons can be classifieds:

- **Motor neurons** that control muscle contractions have a cell body on one end, a long axon in the middle and dendrites on the other end. Motor neurons carry signals from the central nervous system to the other parts (muscles, skin and glands) of body.
- **Sensory neurons** have dendrites on both ends, connected by a long axon with a cell body in the middle. Sensory neurons carry signals from the outer parts of body into the central nervous system.
- **Interneuron or associative neurons** carry information between motor and sensory neurons. These fundamental members of the nervous system also vary with respect to their functions. Interneuron connect various neurons within the brain and spinal cord.

Reflex Action

A reflex action is a rapid automatic response to a stimulus. Reflex actions are involuntary and do not necessarily involve the brain.

Reflex actions protect the body by reacting quickly to danger. When a receptor is stimulated, it sends a signal to the central nervous system, where the brain coordinates the response, but sometimes a very quick response is needed, one that does not involve the brain; that is a reflex action. These are in voluntary responses that occur in direct response to outside stimuli. Reflex actions are rapid and happen without thinking. For example, a person would pull his hand away from a hot flame without thinking about it.

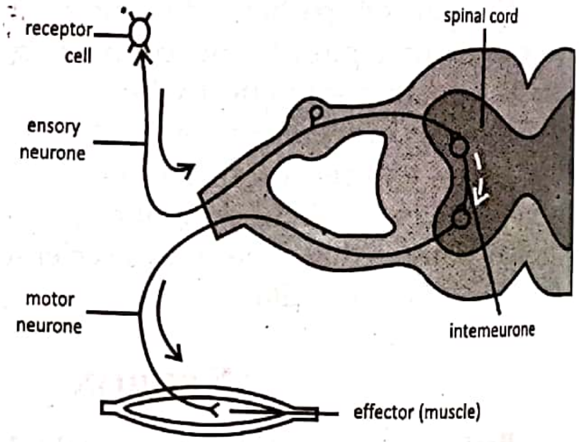


Fig: Reflex Arc

ENDOCRINE SYSTEM

A **hormone** is a chemical released by a gland in one part of the body that sends out messages which affect cells in other parts of the organism. Only a small amount of hormone is required to alter cell metabolism. In essence, it is a chemical messenger that transports a signal from one cell to another. A **gland** is a group of cells that produces and secretes, or gives off, chemicals. A gland selects and removes materials from the blood, processes them and secretes the finished chemical product for use somewhere in the body. Glands are of two principal types: endocrine and exocrine. Exocrine glands release their products onto body surfaces like the skin such as sweat glands or into cavities such as those inside the digestive tract. Endocrine glands secrete hormones directly into the bloodstream for example thyroid glands.

Major Endocrine Glands

Following are the major endocrine glands of the body:

1. Pituitary Gland
2. Thyroid Gland
3. Parathyroid Gland
4. Adrenal Gland
5. Pancreas
6. Gonads (Ovaries and Testes)
7. Pineal Gland

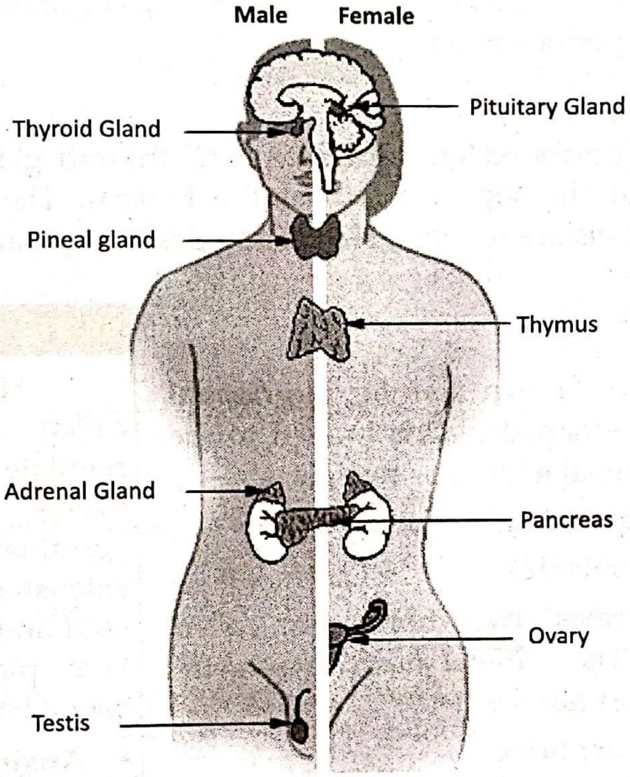


Figure: Endocrine Glands

Pituitary Gland

Pituitary gland is a very small (equal to the size of pea) oval gland lying at the base of the brain. It is also called master gland because it controls the secretions of other glands. It is divided into two sections — an anterior (meaning front) and posterior (meaning back) part because they are formed in different ways. Hormones, released from the *anterior pituitary,* are:

1. Thyroid-stimulating Hormone (TSH)
2. Adrenocorticotrophic Hormone (ACTH)
3. Follicle-stimulating Hormone (FSH)
4. Luteinizing hormone (LH)
5. Prolactin (PRL)
6. Growth Hormone (GH) or Somatotrophin

7. Melanocyte Stimulating Hormone (MSH)

Hormones released from the *posterior pituitary* are:

1. Anti-diuretic Hormone (ADH)/ Vasopressin
2. Oxytocin

Thyroid Gland

Thyroid gland is in the centre of the neck, at the front, below the Adam's apple. It is made of two lobes joined in the centre. The thyroid secretes major hormone called Thyroxin and Calcitonin. To create the thyroxin, the body needs a substance called iodine which is found mainly in salt. Deficiency of iodine can lead to swelling of thyroid gland; a condition termed as Goitre. Low levels of thyroid hormone can result in feelings of tiredness, excessive sleep, loss of sex-drive and less frequent periods in a woman.

Parathyroid Glands

Parathyroid glands are found on the back of the thyroid gland. Most people have four parathyroid glands; two at the top and two at the bottom. The parathyroid releases their hormones when calcium levels are too low. Hormone released by parathyroid gland is known as Parathormone.

Adrenal Glands

Adrenal glands also known as the **suprarenal glands** are yellow pyramid-shaped glands located at the top of the kidneys. Each adrenal gland has two parts:

- Adrenal medulla (inside)
- Adrenal cortex (outside)

Adrenal cortex secretes two hormones called Cortisol and Aldosterone. The adrenal medulla secretes two very important hormones named:

- Adrenaline / epinephrine
- Noradrenalin / nor epinephrine.

Functions of these hormones are similar. These are released during fight, flight and in fear. Their secretion triggers cellular energy use and allows access to the body's energy reserves.

Plant Hormones

Hormones in plants are called phytohormones. They regulate most of the life cycle events in plants, such as germination, cell division and extension, flowering, fruit ripening, seed and bud dormancy and death. Five plant hormones have long been identified. They are:

- **Auxins:** Promote growth
- **Cytokinin:** Promote growth
- **Gibberellins:** Promote growth
- **Abscisic acid:** Inhibits growth
- **Ethylene:** Helps in fruit ripening

Pancreas

Pancreas is a pinkish-grey organ that lies behind the stomach. The organ is approximately 15 cm in length with a long slender body connecting the head and tail segments. The two important hormones released by pancreas are glucagon and insulin. The effects of glucagon are opposite those of insulin. It raises the level of glucose in the blood while insulin reduces the level of glucose.

Gonads

The reproductive components of the endocrine system, called the gonads, secrete sex hormones in response to stimulation from the pituitary gland. Ovaries are located in the pelvis and produce eggs. They also secrete a number of female sex hormones including: oestrogen and progesterone. Testes are located in the scrotum and produce sperm and male sex hormones, or androgens. The androgens, the most important of which is testosterone, regulate development of the reproductive organs, stimulate male secondary sex characteristics and stimulate muscle growth.

Pineal Glands

The pineal gland, also known as the pineal body is a small endocrine gland in the vertebrate brain. The shape of the gland resembles a pine cone, hence its name. The pineal gland is located in the epithalamus, near the center of the brain. The pineal gland produces melatonin, a serotonin derived hormone which modulates sleep patterns in both circadian and seasonal cycles. Here is a table of major human hormones along with their site of production, site of action and brief function.

Major Hormones

Hormone	Gland Origin	Target Tissues	Function
Adrenocortico-tropic	Pituitary Gland	Adrenal cortex	Triggers secretion from the adrenal gland
Growth hormone	Pituitary Gland	Throughout body	Stimulates growth and development
Follicle-stimulating hormone	Pituitary Gland	Sex glands	Stimulates female egg maturation and male sperm production
Luteinizing hormone	Pituitary Gland	Sex glands	Stimulates female ovulation and male secretion of testosterone
Prolactin	Pituitary Gland	Mammary glands	Stimulates milk production in the breasts after childbirth
Thyroid-stimulating hormone	Pituitary Gland	Thyroid gland	Triggers secretion of thyroid hormones
Melanocyte-stimulating hormone	Pituitary Gland	Melanin-producing cells	Controls skin pigmentation
Antidiuretic hormone	Pituitary Gland	Kidneys	Regulates water retention and blood pressure
Oxytocin	Pituitary Gland	Uterus, mammary glands	Triggers contraction of the uterus during labour, stimulates milk letdown for breast-feeding after childbirth
Calcitonin	Thyroid Gland	Bones	Controls the level of calcium in the blood by depositing it in the bones (lowers Ca level)
Thyroid hormone	Thyroid Gland	Throughout body	Increases the body's metabolic rate; promotes normal growth and development

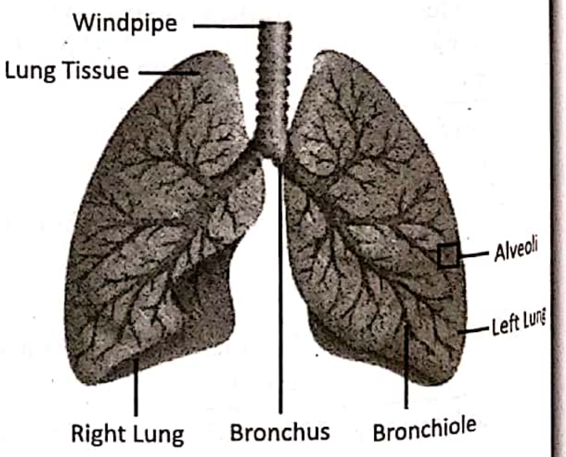
Parathyroid hormone	Parathyroid Glands	Bones, intestines, and kidneys	Regulates calcium level in blood (increases Ca level)
Aldosterone	Adrenal Gland	Kidneys	Regulates sodium and potassium levels in the blood to control blood pressure
Cortisol	Adrenal gland	Throughout body	Plays key role in stress response; increases blood glucose levels and mobilizes fat stores; reduces inflammation
Epinephrine	Adrenal Gland	Muscles and blood vessels	Increases blood pressure, heart and metabolic rate and blood sugar levels; constricts blood vessels. Also released during exercise
Norepinephrine	Adrenal Gland	Muscles and blood vessels	Increases blood pressure and heart rate; dilates blood vessels
Glucagon	Pancreas	Liver	Stimulates the breakdown of glycogen (stored carbohydrate) into glucose (blood sugar); regulates glucose blood level
Insulin	Pancreas	Throughout body	Regulates blood glucose levels; increases storage of glycogen; facilitates glucose intake by body cells
Oestrogen	Ovaries	Female reproductive system	Causes sexual development and growth; maintains proper functioning of female reproductive system
Progesterone	Ovaries	Mammary glands Uterus	Prepares uterus for pregnancy
Testosterone	Testes	Throughout body	Causes sexual development and growth spurt; maintains proper functioning of male reproductive system

RESPIRATORY SYSTEM

Respiration can be defined as *"the breakdown of organic compounds into simpler compounds accompanied by the release of energy in the form of ATP."* Since most often the substrate is glucose, the general equation for respiration can be written as:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38 \text{ ATP (Energy)}$$

There is a pair of lungs in the thoracic cavity — the left lung and the right lung. Lungs are main respiratory organs. The left lung is slightly smaller and has two lobes and the right lung is bigger with three lobes. Each lung is enclosed by two membranes called the outer pleural membrane and the inner pleural membrane or **pleurae**. It protects the lungs. A thick membranous structure, the **diaphragm,** is present below the lungs and separates the thoracic from the abdominal cavity.



Lungs

Respiration Cycle

The respiratory and circulatory systems work together to deliver oxygen to cells and remove carbon dioxide in a two-phase process called respiration. The *first phase* of respiration begins with breathing in, or inhalation. Inhalation brings air from outside the body into the lungs. Here blood is oxygenated and sent to the heart, which pumps the oxygen-rich blood to all parts of the body. Oxygen then moves from the bloodstream into cells, which completes the first phase of respiration. In the cells, oxygen is used to burn the food in a process called *cellular respiration*, which produces carbon dioxide as a by-product.

The *second phase* of respiration begins with the movement of carbon dioxide from the cells to the bloodstream. The bloodstream carries carbon dioxide to the heart, which pumps the carbon dioxide-laden blood to the lungs. In the lungs, carbon dioxide is separated from blood and exhaled, thus completing the respiration cycle.

Respiratory Tract

Nasal Cavity: The respiratory system starts with the nose that encloses the nasal cavity. The nasal cavity opens to the outside through the openings called the nostrils. The nasal cavity is divided into two portions by a cartilaginous septum and is lined by fine hair that filter the dust particles from the air. The nasal cavity is separated from the mouth by hard and soft palate that forms its floor. It opens into the region called the **pharynx**.

Pharynx: Pharynx is common to both food and air. This allows for taking in of more air whenever required and also allows passage of air in case the nose is blocked. Pharynx continues into glottis. It is guarded by a flap of tissue called the *epiglottis*. The epiglottis is thin, lid-like flap of cartilage attached to the base of the tongue of terrestrial vertebrates. The epiglottis is normally pointed upward, but during the passage of solids and liquids from the mouth into the oesophagus, the epiglottis is folded down over the glottis, the opening between the vocal cords, to prevent food from passing into the trachea.

Larynx: Larynx is also called the voice box. It helps in the production of sound. The portion of the tract that carries out this function is the larynx. It has several folds of elastic connective tissues called the vocal chords. They extend from the posterior end of the pharynx to the end of larynx. When air passes through the larynx, these chords vibrate and produce sound.

Trachea: Trachea is also called the windpipe. The trachea is held open with the help of C-shaped cartilaginous rings. The open ends of the rings are towards the oesophagus, the food pipe. The trachea is situated in front of the oesophagus. The cartilages keep the larynx and trachea from collapsing even when there is no air in them. The trachea then branches into two main branches called bronchi.

Bronchi and Bronchioles: Each bronchus (plural bronchi) is also supported by the cartilaginous rings. The bronchus then branches into several bronchioles. The bronchioles progressively lose the cartilages as they become narrower. The bronchioles end as fine tubules called the alveolar ducts. Each alveolar duct opens into an alveolar sac. Alveolar sac is the extended region into which a group of alveoli or air sacs open. **Alveoli** are tiny sacs within our lungs that allow oxygen and carbon dioxide to move between the lungs and bloodstream.

Gas exchange

Within the alveoli, an exchange of gases takes place between the gases inside the alveoli and the blood. Blood arriving in the alveoli has a higher carbon dioxide concentration which is produced during respiration by the body's cells. However, the air in the alveoli has a much lower concentration of carbon dioxide, meaning there is a concentration gradient which allows carbon dioxide to diffuse out of the blood and into the alveolar air.

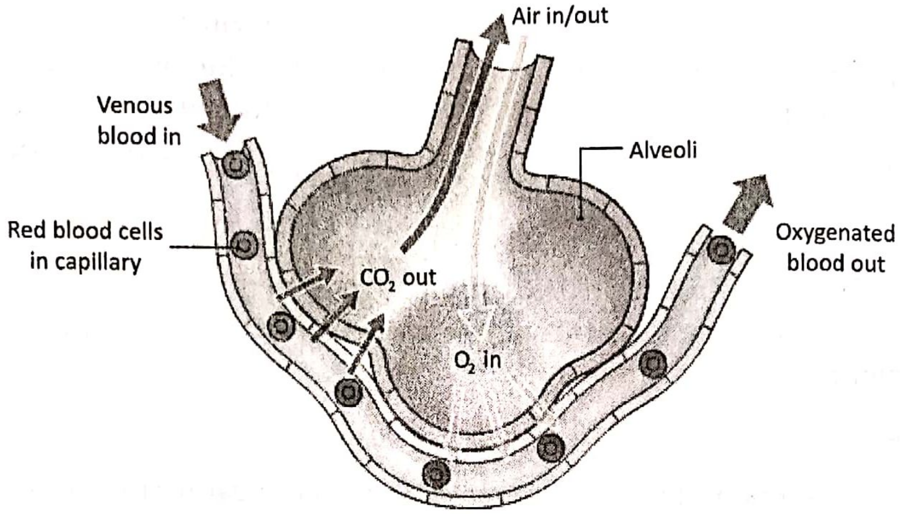


Figure: Gas Exchange in alveoli

Similarly, blood arriving in the alveoli has a lower oxygen concentration (as it has been used for respiration by the body's cells), while the air in the alveoli has a higher oxygen concentration. Therefore, oxygen moves into the blood by diffusion and combines with the haemoglobin in red blood cells to form oxyhaemoglobin.

This table shows the differences (approximate figures) in the composition of inhaled and exhaled air.

Gas	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	79%	79%

DIGESTIVE SYSTEM

Digestion can be defined as *"The process of breaking down food by mechanical and enzymatic action in the stomach and intestines into substances that can be absorbed by the blood."* In humans, proteins must be broken down into amino acids, starches into simple sugars and fats into fatty acids and glycerol. Digestion is chemical and mechanical as it is clear from the above definition. *Chemical digestion* is the action of various enzymes and juices secreted in this process while *mechanical digestion* is simply the aspects of digestion achieved through a mechanism or movement.

Human Digestive Tract

The digestive system is made up of the **alimentary canal** also called the **digestive tract** and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal is the long tube of organs including the oesophagus, stomach and intestines that runs from the mouth to the anus. An adult's digestive tract is about 30 feet (about 9 metres) long.

Oral Cavity: Digestion begins in the **mouth** well before food reaches the stomach. When we see, smell, taste or even imagine a tasty meal, three pairs of **salivary glands** start producing saliva. As the teeth tear and chop the food and this chewing is the part of mechanical digestion called *mastication*. Mucous, present in **saliva,** moistens the food for easy swallowing. A digestive enzyme called **amylase** which is found in saliva starts to break down some of the carbohydrates.

Once food has been reduced to a soft mass, it is ready to be swallowed. The tongue pushes this mass — called a *bolus* — to the back of the mouth and into the **pharynx**. This cavity between the mouth and windpipe serves as a passageway both for food on its way down to the alimentary canal and for air passing into the windpipe. The *epiglottis*, a flap of cartilage, covers the trachea (windpipe) when a person swallows. This action of the epiglottis prevents choking by directing food from the windpipe and toward the stomach.

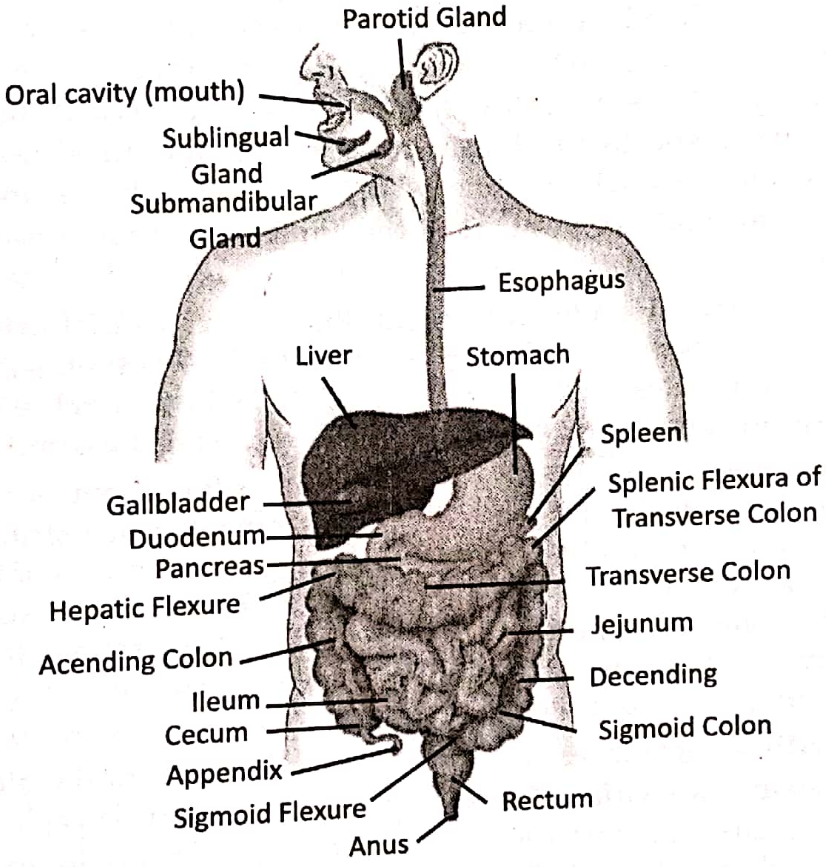


Figure: Human Digestive System

Oesophagus: The presence of food in the pharynx stimulates swallowing, which squeezes the food into the oesophagus. The oesophagus, a muscular tube about 25 cm (10 in) long, passes behind the trachea and heart. Food advances through the alimentary canal by means of rhythmic muscle contractions known as **peristalsis**. The process begins when circular muscles in the oesophagus wall contract and relax (widen) one after the other, squeezing food down toward the stomach. Food travels the length of the oesophagus in two to three seconds.

Stomach: At the end of the oesophagus, a muscular ring or valve called a **sphincter** allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the oesophagus. The stomach muscles *churn* and mix the food with acids and enzymes, breaking it into much smaller digestible pieces. Glands in the stomach-lining produce about 3 quarts (2.8

litres) of digestive juices each day. Gastric juice contains a very strong acid *HCl* having pH 2-3, digestive enzymes, *pepsin*. Acid attacks on microbes and kills them and helps in combustion of food. While pepsin acts on proteins and breaks them into smaller units.

By the time food is ready to leave the stomach, it has been processed into a thick liquid called **chyme.** A walnut-sized muscular valve at the outlet of the stomach called the pylorus keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then pushed down into the duodenum, the first part of small intestine, where digestion of food continues so the body can absorb the nutrients into the bloodstream.

The **small intestine** is the longest organ of the digestive tract. It is divided into three sections: the *duodenum*, the *jejunum* and the *ileum*.

Duodenum: This is the place where the food digestion reaches its completion and where the acidity of chyme is nullified. Secretions from liver and pancreas are secreted here. The liver produces bile which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. The pancreas produces enzymes trypsin, lipase and amylase that help digest proteins, fats and carbohydrates, respectively. These enzymes and bile travel through special channels called ducts directly into the small intestine, where they help to break down food. The liver, the gallbladder and the pancreas are not part of the alimentary canal, however, these organs are essential to digestion.

Glands in the intestinal walls secrete additional enzymes that break down starches and complex sugars into nutrients that the intestine absorbs. The nutrients in the food have almost been broken down to molecules small enough to be absorbed through the intestinal walls into the bloodstream. This absorption of food nutrients into blood is called **assimilation.**

Jejunum and Ileum: Peristalsis pushes the nutrient liquid out of the duodenum into the jejunum and ileum. A greater number of *villi*, microscopic, hairlike structures, begin to absorb amino acids, sugars, fatty acids and glycerol from the digested contents of the small intestine. The greatest number of the estimated five or six million villi in the small intestine are found along the ileum making it the main absorption location of the gastrointestinal tract. The villi here are always in a movement: oscillating, pulsating, lengthening, shortening, growing narrower then wider, absorbing every particle of nutrient.

Beneath the **villi's** single layer of cells there are capillaries of the bloodstream and lacteals of the lymphatic system. Capillaries allow nutrients, produced by digestion, to travel to the cells of the body. Simple sugars and amino acids pass through the capillaries to enter the bloodstream. Fatty acids and glycerol pass through the lacteals to the lymphatic system.

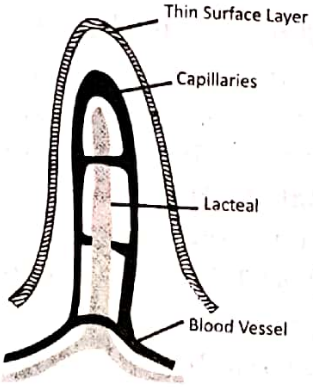


Figure: Alveolus

Large Intestine: A watery residue of indigestible food and digestive juices remains unabsorbed. This residue leaves the ileum of the small intestine and moves by peristalsis into the large intestine. The large intestine forms an inverted U over the coils of the small intestine. It starts on the lower right-hand side of the body and ends on the lower left-hand side.

The large intestine serves several important functions. It absorbs water — about 6 litres (1.6 gallons) daily — as well as dissolves salts from the residue passed on by the small intestine. In addition, bacteria in the large intestine promote the breakdown of undigested materials and make several vitamins, notably vitamin K, which the body needs for blood-clotting.

The large intestine moves its remaining contents toward the rectum. The rectum stores the faeces — waste material that consists largely of undigested food, digestive juices, bacteria and mucus — until elimination. Then, muscle contractions in the walls of the rectum push the faeces toward the anus. When sphincters between the rectum and anus relax, the faeces pass out of the body.

HUMAN LIVER

Humans have five vital organs that are essential for survival. These are the brain, heart, kidneys, liver and lungs. The liver is an abdominal glandular organ in the digestive system. It is located in the right upper quadrant of the abdomen, under the diaphragm. The liver is a vital organ that supports nearly every other organ to some capacity.

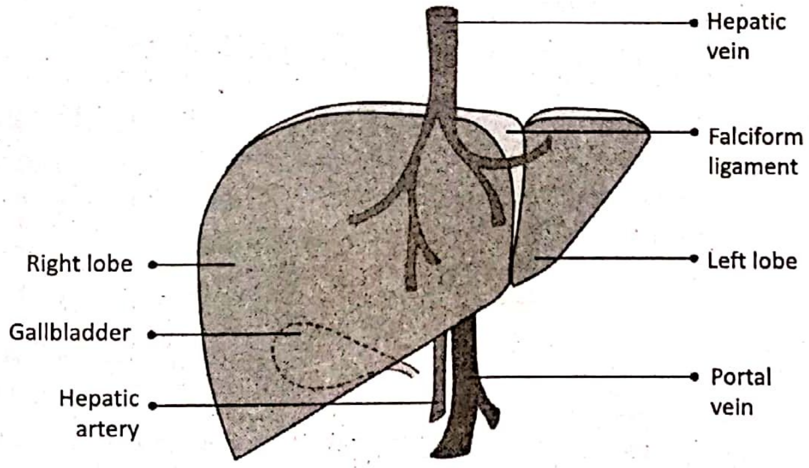


Figure: Structure of Liver

The liver is the body's second-largest organ (skin is the largest organ), according to the American Liver Foundation, weighing about 3 pounds (1.4 kilograms). It has four lobes and is a very soft, pinkish brown organ. It contains several bile ducts.

Function

The liver has a complex role in the function of the body. Detoxification, metabolism (including regulation of glycogen storage), hormone regulation, protein metabolism, digestion, and decomposition of red blood cells, to name a few. It produces bile, a chemical substance that breaks down fats and makes them more easily digestible.

The liver also produces and synthesizes multiple important elements of plasma, and stores some vital nutrients, including vitamins (especially A, D, E, K, and B-12) and iron. It also stores simple sugar glucose and converts it to usable glucose if your blood sugar levels fall. One of the best-known roles of the liver is as a detoxification system. It removes toxic substances from blood, such as alcohol and drugs. It also breaks down haemoglobin, insulin and excessive hormones to keep hormone levels in balance. Additionally, it destroys old blood cells.

The liver is vital for healthy metabolic function. It metabolizes carbohydrates, lipids and proteins into useful substances, such as glucose, cholesterol, phospholipids and lipoproteins that are used in various cells throughout the body. The liver breaks down the unusable parts of proteins and converts them into ammonia, and eventually urea.

EXCRETORY SYSTEM

The excretory system is the system of an organism's body that performs the function of excretion, the bodily process of discharging wastes. The Excretory system is responsible for the elimination of wastes produced by homeostasis. There are several parts of the body that are involved in this process, such as sweat glands, the liver, the lungs and the kidney system.

Urine is produced by the kidneys and it contains the by-products of metabolism (salts, toxins and water) that end up in the blood. The kidneys and urinary tract filter and eliminate these waste substances from our blood. Without the kidneys, waste products and toxins would soon build up in the blood to dangerous levels.

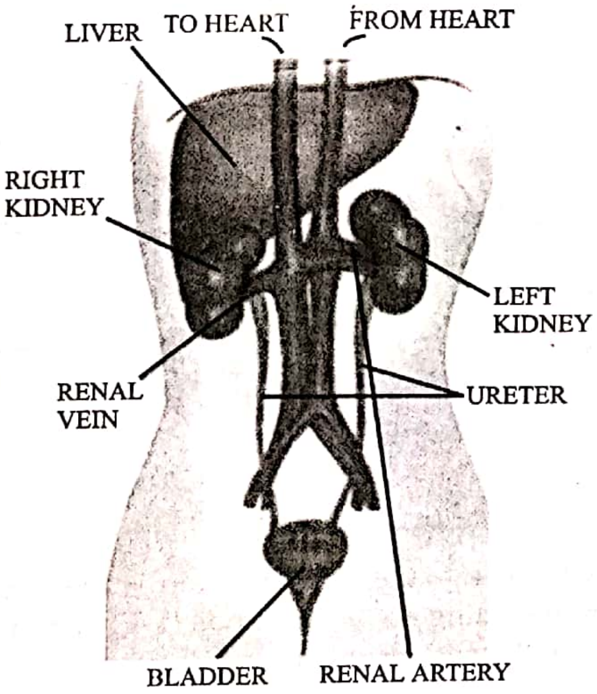


Figure: Human Urinary System

In addition to eliminating wastes, the kidneys and urinary tract also regulate many important body functions.

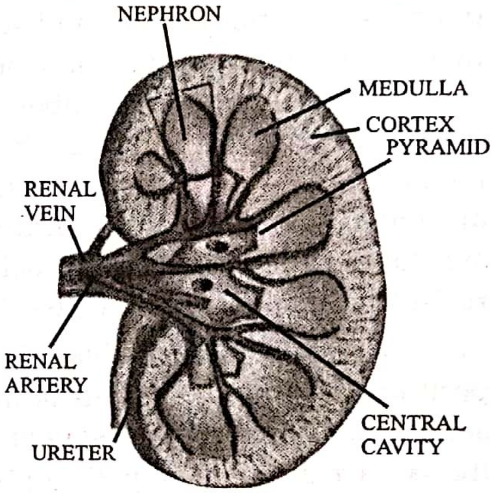
1. The kidneys monitor and maintain the body's *balance of water*, ensuring that our tissues receive enough water to function properly and be healthy.

2. The kidneys also *regulate blood pressure* and the level of vital salts in the blood. By regulating salt levels through production of an enzyme called *rennin* (as well as other substances).
3. The kidneys also secrete the hormone *erythropoietin*, which stimulates and controls red blood cell production.
4. The kidneys help regulate the *acid-base balance* (or the pH) of the blood and body fluids, which is necessary for the body to function normally.

Kidneys

The kidneys are dark-red, slightly flattened, bean-shaped organs about 10 cm long, 5 cm wide and 4 cm thick and each weighing about 270 g. They are placed against the back wall of the abdominal cavity just below the diaphragm, one on either side of the vertebral column. They are protected by the last two ribs. The kidneys are covered by the *peritoneum* in the front and on the side and they rest against the abdominal muscles. Their position is slightly asymmetrical; the left kidney is a little higher than the right one.

Each kidney is bean-shaped. The outer surface is convex and the inner surface is concave. The inner surface has a deep notch called *hilus*. The ureters, renal artery, renal vein and the nerves enter the kidney through the hilus. Each kidney is composed of numerous microscopic coiled tubules called *nephron* or renal tubules or uriniferous tubules. The kidney is divided into two regions; the outer region is called *renal cortex* and the inner region termed *renal medulla*. The medulla is subdivided into conical masses, the *renal pyramids*, each having a broad base towards the cortex and a narrow end called renal papilla towards the pelvis.



Ureters, Urinary Bladder and Urethra

Ureters conduct urine from the kidneys to the urinary bladder. Urinary bladder is a pear shaped sac situated in the pelvic region of the abdominal cavity. It can store about 0.5 to 1 litre of urine. The urethra starts from the neck of the urinary bladder and leads to the exterior. In females, it is about 2 - 3 cm long and carries only urine. It opens by the urethral opening or urinary aperture in the vulva in front of the vaginal or genital aperture. In male, urethra is about 20 cm long and carries urine as well as the spermatic fluid. It passes through the penis and opens out at the tip of the penis by a urinogenital aperture.

Structure of a Nephron

The nephron or uriniferous tubule is the functional unit of the kidney. A nephron consists of a twisted tubule closed at one end, open at the other with a network of associated blood vessels. Each kidney of man is formed of about *one million nephrons*. Each nephron has a length of about 3 cm. It is differentiated into four regions having different anatomical features and different physiological roles.

The four regions are:

1. Bowman's capsule
2. Proximal convoluted tubule (PCT)
3. Loop of Henle
4. Distal convoluted tubule (DCT)

Each of the nephrons contains a filter called the **glomerulus** which consists of a network of tiny blood vessels known as capillaries. The fluid filtered from the blood by the glomerulus travels down a tiny tube-like structure called a tubule.

Function of Nephron

The main functions of the nephron are related to filtering, reabsorbing and secreting glutamate, carbohydrates and solutes. The glomerulus has two cell layers as well as a basement membrane that separate it from the Bowman's capsule. This basement membrane contains collagen and glycoprotein fibers. These fibers have a mesh-like structure that uses ultrafiltration to filter the blood. Although the smaller molecules in the blood are able to pass through this membrane, larger molecules such as blood cells and proteins cannot. This process removes around 70% of the solutes and water from a person's blood plasma. It also filters some useful substances including amino acids and glucose but selective reabsorption allows the body to reabsorb them and keep the electrolyte levels balanced.

After the fluid is filtered, it goes into the proximal tubule where it is reabsorbed into the peritubular capillaries. This is the point at which any essential substances (such as ions, amino acids, vitamins and glucose) get transported back to the blood. The numerous microvilli increase the surface area, making absorption more effective. While the substances are re-added, the solute concentration found of the blood in these capillaries increases. This means that a great deal of water must go back into the blood while in the proximal tubule using osmosis as this will balance electrolyte levels.

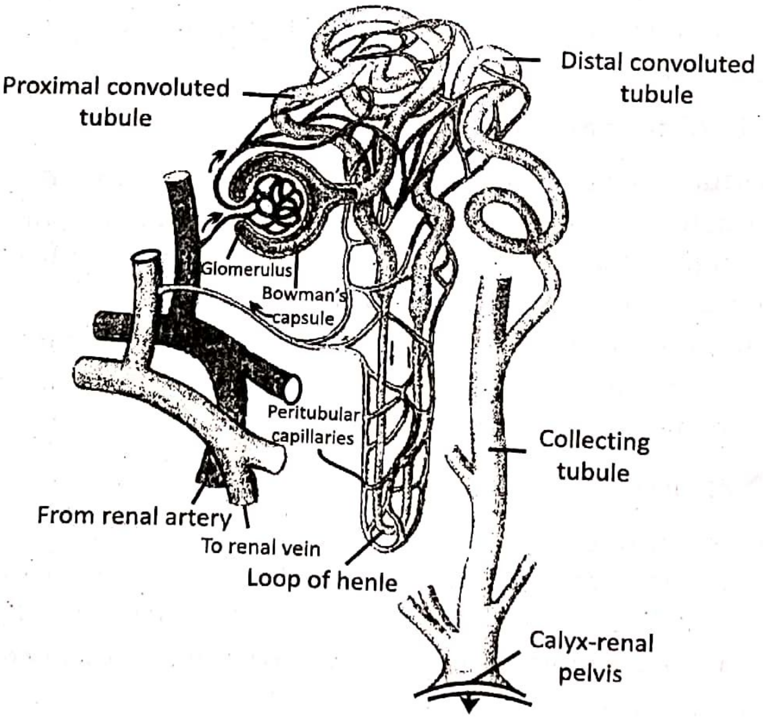


Figure: Nephron

The loop of Henle concentrates the salts which are added to the urine for excretion, creating a high solute concentration found in the medulla. The limbs of this loop of Henle are able to reabsorb certain solutes, water and ions due to their permeable nature. These substances are reabsorbed from the area in the collecting ducts which go through this area of the nephron. The ascending limb is highly permeable to salts than water so during the absorption of these salts, more water exits the descending limb which in turn creates concentrated urine. This substance is then drained so that it enters the distal convoluted tubule, a feature which is responsible for maintaining balanced pH levels of both blood and urine. After this, the fluid continues on its way to the collecting duct for another process of ultrafiltration before going to the ureters followed by the bladder.

MUSCULOSKELETAL SYSTEM

The musculoskeletal system provides form, support, stability, and movement to the body. It is made up of the bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissue that supports and binds tissues and organs together. The human skeleton has 206 bones.

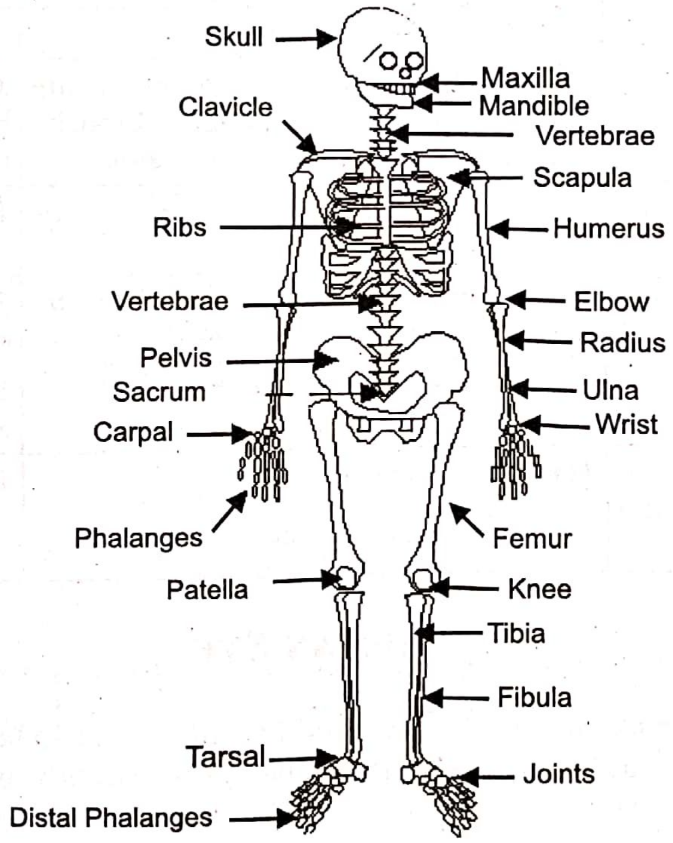


Figure: Human Skeleton

The Functions of Skeleton

The skeleton has five main functions:

1. **Support:** The skeleton supports the soft tissues of the body as it forms a rigid framework to which our muscles, tendons, ligaments, etc. attach.

2. **Shape:** The overall shape of our bodies is mostly due to our skeletons, e.g. our skeleton determines if we are short or tall by how long our bones are.
3. **Protection:** Our bones are very strong and can provide protection to the vital organs, e.g. the skull protects the brain, and the ribs and sternum protect the heart and lungs.
4. **Movement:** Our bones are levers which are pulled by the muscles to cause movement.
5. **Making blood cells:** Inside long bones is a substance called bone marrow, which makes new blood cells.

Muscles and their Function

Bones don't work alone. They need help from the muscles and joints. Muscles pull on the joints, allowing us to move. They also help our body perform other functions so we can grow and remain strong, such as chewing food and then moving it through the digestive system. The human body has more than 630 muscles, which make up half of a person's body weight. Muscles can be divided into skeletal, smooth and cardiac on the basis of their structure and function. Here is the comparison of these muscles.

Skeletal Muscle	Smooth Muscle	Cardiac Muscle
They are directly attached to the skeleton.	Main locations of involuntary muscle are ducts of glands, oesophagus, bronchi, intestines, stomach and blood vessels.	They are found only in the heart and at the cardiac ends of the main blood vessels.
They help in movement and locomotion.	They maintain flow of fluids and foods along its hollow structures.	They help in rhythmic contractions of heart.
It is under the voluntary control.	They contract involuntarily regulated by the autonomic nervous system.	They are controlled by the central nervous system.
They are striated muscles.	They are smooth in appearance.	They would be striated in appearance.
They fatigue rapidly in comparison to smooth and cardiac muscles.	They fatigue slowly.	They don't fatigue.

HUMAN EYE

Our eyes are vital for seeing the world around us, but vision can be impaired by a number of medical conditions, as well as the ageing process. The eye is a slightly asymmetrical globe, about one inch (2.5 cm) in diameter.

The front part of the eye (the part you see in the mirror) includes:

- The iris (the pigmented part)
- The cornea (a clear dome over the iris)
- The pupil (the black circular opening in the iris, which lets light in)
- The sclera (the white part)
- The conjunctiva (an invisible, clear layer of tissue covering the front of the eye, except the cornea)

The **iris** is the colored part of the eye. It is important because it controls the size of the **pupil**. The pupil is the dark circle inside the center of the eye. The dark hole is altered in shape by the iris, affecting the amount of light that is let into the eye. The pupil is large when light is low or it is dark outside and tiny when it is very sunny or bright.

The **cornea** is the clear covering over the pupil and iris. This is the reason that contacts are dome shaped because they sit on the cornea. The cornea provides 66% of the optic power that the overall eye has. This means that the cornea is very important in focusing what we see by bending light. The **sclera** is the white part of the eye that we see in the mirror that becomes pink or red when we are tired or have sneezed so hard our eyes become bloodshot. This eye part is the protective, outer layer of the eye. It is made up of elastic-like fibers called **elastin** and **collagen**, a common connective tissue found in mammals.

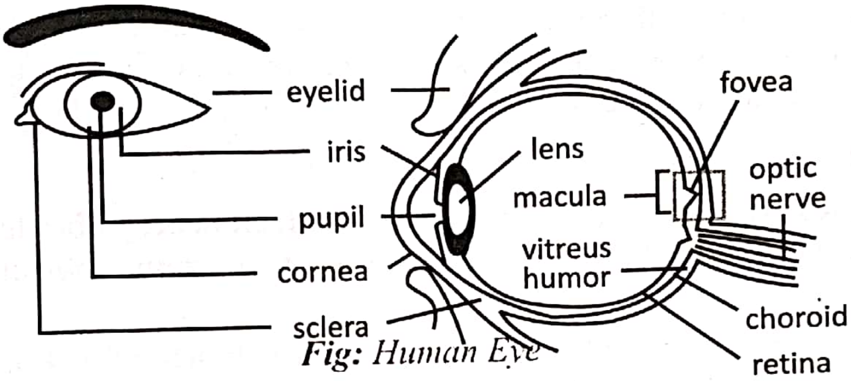


Fig: Human Eye

The eyeball is held in place by the **eyelid**, which is the first protective layer. The eyelid has an inner layer of skin called **conjunctiva**. The conjunctiva covers the sclera and provides mucus and tears for eye lubrication and bacterial infection prevention. It does not cover the cornea.

In the back of the eye, are the important items that we cannot see when we look in the mirror. This area consists of the:

- Lens
- Vitreous body
- Retina
- Macula and
- Optic nerve

The part of the eye immediately behind the iris that performs delicate focusing of light rays upon the retina is lens of the eye. It's a **convex lens** and its thickness is controlled by the *ciliary muscles*.

Retina is the innermost layer of the eye that contains photoreceptor cells. These photoreceptor nerve cells react to the presence and intensity of light by sending an impulse to the brain via the optic nerve. The part of the retina which is most sensitive and is responsible for the central or reading vision is called *macula, or yellow spot*. It is located near the optic nerve directly at the back of the eye. This area is also responsible for colour vision.

Vitreous body is a gel-like transparent substance located in the posterior part of the eye. The vitreous body supports the sphere of the eye ball and is part of the intraocular metabolism. It is a part of the optic system.

The optic nerve is the structure which takes the information from the retina as electrical signals and delivers it to the brain where this information is interpreted as a visual image. The optic nerve consists of a bundle of about one million nerve fibres.

The eye's retina contains millions of tiny light-sensing nerve cells called rods and cones, which are named for their unique shapes.

- Cones are responsible for perceiving colour and detail.
- Rods and responsible for night vision, peripheral or side vision, and detecting motion.

Rods and cones convert the light from our retinas into electrical impulses, which are sent by the optic nerve to the brain, where an image is produced. The central part of the retina, called the macula, is about the size of a pencil eraser. It is this small area that gives us central vision needed for activities like reading, driving, and working on the computer. The position in the back of the eye, where the nerve along with an artery and vein enters the eye, corresponds to the "blind spot" since there are no rods or cones in this location. No image is formed there; therefore it is termed as blind spot, scotoma or optic disc.

Disorders of Eye

Nearsightedness (Myopia): It is a condition in which nearby objects are seen more clearly than distant objects because light is focused in front of the retina, not on it. It is corrected by concave lens.

Farsightedness (Hyperopia): It is a condition in which distant objects are seen more clearly than nearby objects because light is focused behind the retina, not on it. It is corrected by convex lens.

Cataract: Cataract is a condition in which the lens of the eye becomes dense or opaque and does not properly transmit light. It causes blurry vision.

Colour blindness: Colour blindness is an inherited condition. The retina contains cells that are sensitive to red, green or blue light. People with colour blindness have a lack of receptors, or defects in them. People with red-green colour blindness, for example, have difficulty distinguishing shades of red and green.

HUMAN EAR

Our ears are in charge of collecting sounds, processing them, and sending sound signals to brain. And that's not all —ears also help keep balance. The ear is made up of three different sections: **the outer ear, the middle ear,** and the **inner ear.** These parts all work together so you can hear and process sounds. The outer and middle ear structures are involved with hearing only while the inner ear functions in both equilibrium and hearing.

The outer ear consists of an outer, funnel-like structure called the **auricle** (or **pinna**) and an S-shaped tube, the **external auditory meatus** or auditory canal. The auricle of the ear helps to collect sound waves travelling through air and directs them into the auditory meatus. Sound waves entering the external auditory canal eventually hit the **tympanic membrane** or eardrum. It's the boundary between the outer and middle ears. Sound waves make the eardrum vibrate; the eardrum, in turn, transfers the sound energy to the tiny bones of the middle ear and sets them into vibration.

The **middle ear** consists of an air-filled space having three small bones called auditory ossicles. The auditory ossicles being the smallest bones in the body are named according to their shape — the **malleus** (hammer), **incus** (anvil), and **stapes** (stirrup). The handle of the malleus is attached to the eardrum, and the base of the stapes fits into the oval window. A **Eustachian tube** (**auditory tube**) connects middle ear to the throat. This tube allows air to pass between the tympanic cavity and the outside of the body by way of the throat and mouth. It is important to maintain equal air pressure on both sides of the eardrum, which is important for normal hearing.

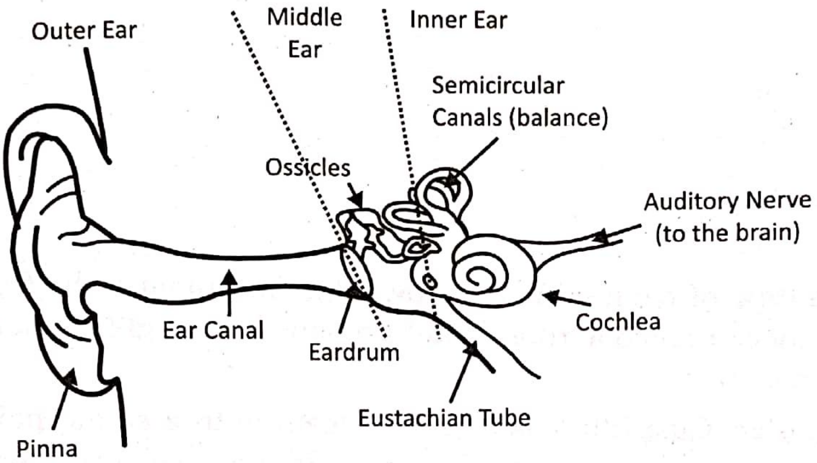


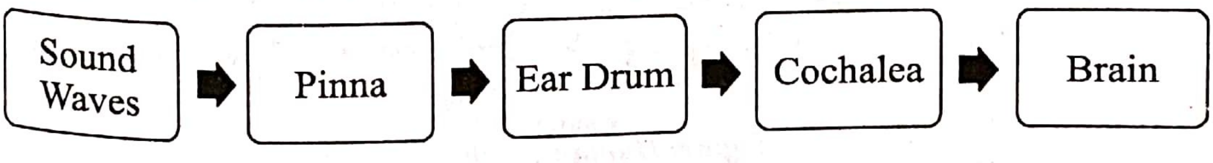
Figure: Human Ear

The second step in hearing is the transmission of sound energy from the tympanic membrane through the **middle-ear cavity** to the inner ear. **The inner ear** consists of a complex system of inter-communicating chambers and tubes called a **labyrinth**. The parts of the labyrinths include a **cochlea** that functions in hearing, and three **semicircular canals** (anterior, posterior and lateral) that function in providing a sense of equilibrium. A bony chamber, called the **vestibule**, located between the cochlea and the semicircular canals, contains membranous structures that serve both hearing and equilibrium.

The cochlea, as its name suggests, is shaped like the coiled shell of a snail. Inside, it contains a bony core and a thin bony shelf that winds around the core like threads of a screw. They are filled with **perilymph**. It contains many thousands of stiff, elastic fibres, whose lengths vary becoming progressively longer from the base of the cochlea to its apex. Vibrations entering the perilymph cause movements in these fibres or cilia. These fibres generate a message that is sent to the brain through auditory nerve.

Mechanism of Hearing

When sound waves hit our eardrum, a chain reaction is set off. Our eardrum sends the vibrations to the three smallest bones in our body. The stirrup passes those vibrations along a coiled tube in the inner ear called the cochlea. Inside the cochlea, there are thousands of hair-like nerve endings, cilia. When the cochlea vibrates, the cilia move. A nerve message generates that is sent to the brain through the auditory nerve. Our brain then translates all that and tells us what we are hearing. Sound waves travel in the following way to send the message to brain:



HUMAN TEETH

People have two sets of teeth in their lives, the primary teeth (also called the baby, milk or deciduous teeth) and the permanent teeth (also called the adult or secondary teeth). Children have 20 primary teeth, which start erupting at the age of six months up to three years. They are replaced by the permanent teeth at about 13. Adults have 32 permanent teeth.

Teeth Types

Incisors	8
Canines	4
Premolars	8
Molars	12

Incisors: It is a type of teeth with a narrow edge (in humans, the front teeth). Incisors are used to cut food. An incisor has one root. Adult humans have eight incisors (four in the top jaw and four in the bottom jaw).

Canine (also called Cuspid): It is a type of teeth with a single point (also called canine tooth) and a single root. Cuspid teeth are used to hold and tear food. Adults have four canine teeth (two in the top and two in the bottom jaw). Canine means "of or like a dog."

Premolar (also called Bicuspid): This type of teeth is located between the canine and the molars in humans. A bicuspid tooth has one root. Bicuspids have two points (cusps) at the top. Adults have eight premolars (four in the top and four in the bottom jaw).

Molar: A wide, flat tooth found in the back of mammal's mouths is called molar. Molars grind food during chewing. Molars in the top jaw have three roots; molars in the lower jaw have two roots. Adults have 12 molars (six in the top jaw and six in the bottom jaw). **Wisdom teeth** (also called the third molars) are molars that usually erupt from the age of 17 to 21.

Structure of Tooth

Tooth Enamel: Tooth enamel is the hardest of the parts of the tooth and also the hardest of all the tissues of human body. Tooth enamel is a protective structure that covers the exposed part of a tooth, the crown. Enamel is inorganic and non-living part of the bone.

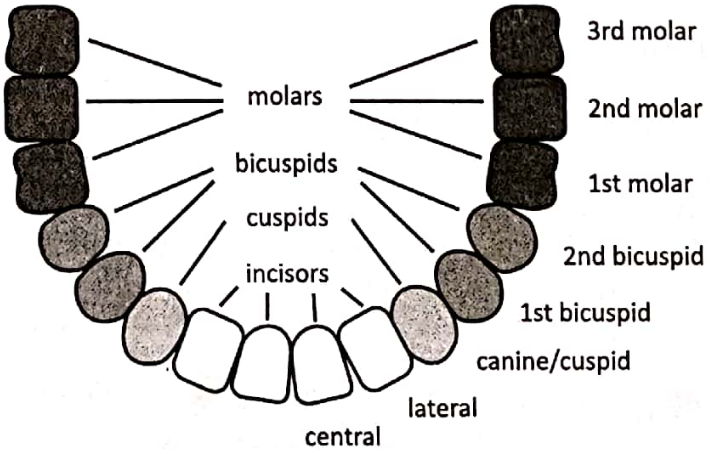


Figure: Human Teeth

Dentine or Ivory: Dentine is the soft bony tissue below the tooth enamel that forms the main mass of a tooth. It supports the tooth enamel and absorbs the pressure of eating. The dentine consists of a number of micro-fibres imbedded in a dense homogeneous matrix of collagenous proteins.

Dental Pulp: Pulp is a soft connective tissue containing nerves and blood vessels that nourish the tooth. It is the most internal structure of a tooth, surrounded by the dentine. Dental pulp is found in the soft centre of the tooth, inside the pulp chamber and the root canal.

Cementum: Cementum is the part of tooth anatomy that covers the dentine outside the root (under the gum line) and it is attached to the bone of the jaw with little elastic fibres. Cementum is hard as bone but not as hard as the tooth enamel.

Gums: Gums are the tough pink-coloured tissues that cover the bone of the jaw and support the tooth structure inside the alveolar bone. The internal tooth structure is common in all types of teeth, but the external teeth parts morphology (shape of tooth crown, number and shape of roots) differs significantly between different teeth types.

HUMAN PHYSIOLOGY (MCQS)

Note: **Answers are Bold and Underlined:**

1. **Which of the following is not true regarding saliva?**
(a) It contains digestive enzymes. (b) It is a colourless fluid.
(c) **It doesn't have any role in swallowing of food.**
(d) It is secreted by salivary glands.

2. **Most of the water in the alimentary tract is absorbed through:**
(a) Oesophagus (b) **Large intestine**
(c) Stomach (d) Small intestine

3. **Villi are not found in:**
(a) Colon (b) **Stomach** (c) Ileum (d) Jejunum

4. **A tooth is made up of a solid bony tissue known as:**
(a) Root (b) Crown (c) Enamel (d) **Dentine**

5. **Which is the largest internal organ in the human body?**
(a) **Liver** (b) Pancreas
(c) Large intestine (d) Small intestine

6. **The surface of the crown of the tooth is covered with a strong protective layer called:**
(a) Cavity (b) **Enamel** (c) Dentine (d) Root

7. **Which of the following prevents food from entering the trachea (wind pipe)?**
(a) Larynx (b) **Epiglottis** (c) Pharynx (d) Glottis

8. Which is not a part of the small intestine?
(a) Caecum (b) Duodenum (c) Jejunum (d) Ileum

9. Which of the following is the common passage for the food eaten and the air breathed?
(a) Oesophagus (b) Larynx (c) Trachea (d) Pharynx

10. There are _____ pairs of salivary glands present in the mouth.
(a) 2 (b) 3 (c) 4 (d) 6

11. Which is not a part of the large intestine?
(a) Ileum (b) Caecum (c) Rectum (d) Colon

12. Tuft of capillaries inside the Malpighian body is known as:
(a) Glomerulus (b) Collecting ducts
(c) Nephrons (d) Renal artery

13. Which of these is not a normal constituent of urine: sugar, urea or creatinine?
(a) Urea (b) Sugar (c) Creatinine (d) All of these

14. Which process does not occur in the nasal cavity?
(a) Trapping of large foreign bodies (b) Exchange of gases
(c) Humidification of inhaled air (d) Warming of inhaled air

15. Exchange of air occurs in _____which are also known as 'air sacs'.
(a) Alveolar ducts (b) Bronchi (c) Bronchioles (d) Alveoli

16. Write the correct sequence of the pathway through which air travels after entering the body.
(a) Larynx, pharynx, trachea bronchioles (b) Pharynx, larynx, trachea, bronchioles
(c) Pharynx, larynx, bronchioles, trachea (d) Pharynx, trachea, larynx, bronchioles

17. Normal rate of respiration in an adult human being is _____ times/ minute.
(a) 10-12 (b) 12-20 (c) 16-18 (d) 22-24

18. _____________ investigates the body's structure, whereas __________ investigates the processes or functions of living things.
(a) Physiology, cytology (b) Physiology, anatomy
(c) Anatomy, histology (d) Anatomy, physiology

19. What is the normal heart rate of a adult man / woman.
(a) 30-70 (b) 40-80
(c) 60-100 (d) 80-100

20. Universal blood donor belongs to the blood group:
(a) A (b) B (c) AB (d) O

21. Which of the following is produced by pancreas?
(a) Oxytocin (b) Calcitonin (c) Insulin (d) Estrogen

22. Besides ATP, the end products of aerobic respiration are:
(a) Lactic acid and pyruvic acid. (b) Lactic acid and citric acid.
(c) Carbon dioxide and water. (d) Carbon dioxide, lactic acid and water.

23. Anaerobic respiration produces __________ ATPs and __________ as a waste product.
(a) 38, carbon dioxide (b) 38, lactic acid (c) 2, water (d) 2, lactic acid

24. Aerobic respiration produces _______ ATPs and ______ require oxygen.
(a) 2, does not (b) 2, does (c) 38, does (d) 38, does not

25. Given these parts of a nephron: (1) renal corpuscle, (2) collecting duct, (3) loop of Henle, (4) distal tubule, and (5) proximal tubule. Arrange the parts in order as fluid flows from the filtration membrane through the nephron.
(a) 1,5,3,4,2 (b) 2,4,1,3,5 (c) 2,1,4,5,3 (d) 4,2,3,5,1

26. In a normal human cell, there is (are) __________ pair(s) of autosomal chromosomes, and __________ pair(s) of sex chromosomes.
(a) 23, 23 (b) 23, 1 (c) 22, 1 (d) 21, 2

27. Which organ system removes substances from the blood, combats disease, maintains tissue fluid balance, and absorbs fat from the digestive tract?
(a) Endocrine (b) Integumentary (c) Lymphatic (d) Respiratory

28. Which organ system consists of hormone-secreting glands, such as the pituitary and thyroid glands?
(a) Endocrine (b) Integumentary
(c) Lymphatic (d) Respiratory

29. The wrist consists of eight __________ bones:
(a) Tarsal (b) Carpal
(c) Metacarpal (d) Metatarsal

30. Muscle cells that are cylindrical and branched, each with a single, centrally located nucleus, and that contract spontaneously are:
(a) Cardiac muscle (b) Skeletal muscle
(c) Smooth muscle (d) All of these

31. The largest percentage of plasma is:
(a) Proteins (b) Ions (c) Nutrients (d) Water

32. All of the formed elements of the blood are derived from:
(a) Erythrocytes (b) Leukocytes (c) Platelets (d) Stem cells

33. What are the leukocytes that produce antibodies and other chemicals?
(a) Basophils (b) Eosinophils
(c) Lymphocytes (d) Monocytes

34. Blood is a type of ________ tissue.
(a) Epithelial (b) Nervous (c) Connective (d) Muscular

35. The liquid component of blood with the clotting factors removed is the:
(a) Serum (b) Plasma (c) Lymph (d) Cytoplasm

36. Specialized lymphatic vessels located in the lining of the small intestine that help with absorption of fats and other substances from the digestive system are:
(a) Villi (b) Nephrons (c) Lacteals (d) Tonsils

37. The transparent anterior portion of the outer eye coat which allows light rays to enter the interior of the eye is the:

(a) Conjunctiva (b) Cornea (c) Iris (d) Sclera

38. The coloured (blue, brown, green) portion of the eye, as seen in an anterior view, is which of the following?

(a) Choroid (b) Ciliary body (c) Cornea (d) Iris

39. Clouding of the lens occurs in which of these eye disorders?

(a) Cataract (b) Glaucoma (c) Strabismus (d) Trachoma

40. Contraction of which of the following muscles is involved with changing the shape (thickening) of the lens?

(a) Ciliary muscles (b) Circular muscles of the iris

(c) Orbicularis oculi (d) Radial muscles of the iris

41. Which layer of the eye contains the photoreceptor cells?

(a) Choroid (b) Ciliary body (c) Retina (d) Sclera

42. Which of the following is commonly called the "blind spot" of the eye because it lacks photoreceptor cells?

(a) Canal of Schlemm (b) Fovea centralis (c) Optic disc (d) Pupil

43. An eye that is too long, or "oval," results in poor distance vision, a disorder called nearsightedness or:

(a) Astigmatism (b) Hyperopia (c) Myopia (d) Presbyopia

44. The lipid hormones are either __________ or derivatives of fatty acids.

(a) Glycolipids (b) Phospholipids (c) Steroids (d) Triglycerides

45. The hypothalamus:

(a) Regulates the secretory activity of the pituitary gland.

(b) Is connected to the pituitary gland by the optic chiasma.

(c) Has neurons that connect to the anterior pituitary.

(d) Contains the infundibulum, which secretes many hormones.

46. Oxytocin secretion causes:

(a) Milk ejection in lactating females. (b) Uterine contractions.

(c) Increased urine volume. (d) Both (a) and (b)

47. Anterior pituitary hormones:

(a) Have a long half-life. (b) Bind to intracellular receptors.

(c) Include oxytocin and ADH. (d) Are proteins,

48. The acid that helps in digestion is:

(a) Sulphuric acid (b) Hydrochloric acid

(c) Acetic acid (d) None of these

49. Bile is secreted by:

(a) Pancreas (b) Spleen (c) Stomach (d) Liver

50. The largest organ of the human body is:
(a) External (b) Skin (c) Liver (d) Esophagus

51. The process by which large pieces of food are cut and crushed into smaller pieces is called:
(a) Emulsification (b) Mechanical digestion
(c) Absorption (d) Peristalsis

52. The enzyme in saliva helps to digest:
(a) Carbohydrates (b) Proteins (c) Fats (d) Minerals

53. The gastric juice produced in the stomach contains mucus, hydrochloric acid, and:
(a) Bile (b) Lipase (c) Chime (d) Pepsin

54. The wavelike movement of muscle of the digestive system is called:
(a) Chemical digestion (b) Emulsification
(c) Absorption (d) Peristalsis

55. The enzyme that digests proteins is:
(a) Pepsin (b) Chyme (c) Lipase (d) Bile

56. The tube that connects the mouth to the stomach is the:
(a) Epiglottis (b) Esophagus (c) Pancreas (d) Liver

57. The process of breaking down large droplets of fat into small droplets of fat is called:
(a) Emulsification (b) Absorption (c) Peristalsis (d) Digestion

58. Lipase, an enzyme found in the small intestine, digests:
(a) Carbohydrates (b) Fats and oils (c) Proteins (d) Starches

59. The digestion of all types of nutrients is completed in the:
(a) Stomach (b) Esophagus
(c) Small intestine (d) Large intestine

60. Food that leaves the stomach is in the form of a thick liquid is called:
(a) Bile (b) Villus (c) Chyme (d) Pepsin

CHAPTER 12

HUMAN HEALTH AND DISEASES

Infectious diseases are diseases that are caused by organisms known as **pathogens.** They are sometimes called communicable diseases as they are passed from infected to uninfected people. Some also affect animals and are passed from animals to humans. Disease' is a difficult word to define satisfactorily as it covers a wide range of human conditions. A working definition is given below. "A **disease** is an illness or disorder of the body or mind that leads to poor health; each disease is associated with a set of signs and symptoms".

IMMUNE SYSTEM

Immunity is the protection against disease provided by the body's internal defence or immune system. The external cellular and chemical barriers that protect us from infection are part of that defence system.

External defence System

We have a variety of mechanisms to protect ourselves against infectious diseases. Many pathogens do not harm us because chemical and cellular defences that prevent them entering. For example, the epithelia that cover the airways are an effective barrier to the entry of pathogens; hydrochloric acid in the stomach kills many bacteria that we ingest with our food and drink; blood clotting is a defence mechanism that stops the loss of blood and prevents the entry of pathogens through wounds in the skin.

Internal defence system

If pathogens do successfully enter the body, white blood cells can recognise them as something foreign and destroy them. White blood cells are part of the immune system and they recognise pathogens by the distinctive, large molecules that cover their surfaces, such as proteins, glycoproteins, lipids and polysaccharides, and the waste materials which some pathogens produce. Any molecule which the body recognises as foreign is an **antigen.**

There are two types of white blood cell, namely **phagocytes** and **lymphocytes.** Before looking at their structure and function in detail, it will be useful to look at an example of the immune response in humans. This example introduces further important features of the immune system, namely the ability to distinguish between self and non-self, and the production of antibodies. Antibodies are glycoprotein molecules that act against specific antigens.

Each of us has molecules on the surfaces of our cells that are not found in other organisms, or even in other humans. These are often called cell surface antigens. Although they do not stimulate production of antibodies in us, they will do if they enter someone else. The cell surface antigens of the human ABO blood group system are a good example. If you are blood group A, then you have certain glycolipids on your red blood cells that are not on the red cells of people who are blood group B. If blood of type A is given to someone who has blood of type B during a transfusion, then the recipient will recognise these blood cells as foreign and start to produce antibodies. The recipient's immune system has recognised the antigens on blood cells of type A as **non-self**. If blood of type B is used during the transfusion, as it should be, then the recipient's immune system recognises the antigens on the red blood cells as **self** and no antibodies are produced.

The response of lymphocytes to the presence of a foreign antigen is known as **the immune response**. In some cases lymphocytes respond by producing antibodies; in others they respond by killing cells that have become infected by pathogens.

Cells of the Immune System

The cells of the immune system originate from the bone marrow. There are two groups of these cells involved in defence:

- phagocytes (neutrophils and macrophages)
- lymphocytes.

Phagocytes

Phagocytes are produced throughout life in the bone marrow. They are stored there before being distributed around the body in the blood. They are scavengers, removing any dead cells as well as invasive microorganisms.

Neutrophils are a kind of phagocyte and form about 60% of the white cells in the blood. They travel throughout the body, often leaving the blood by squeezing through the walls of capillaries to 'patrol' the tissues. During an infection, neutrophils are released in large numbers from their stores, but they are short-lived cells. Macrophages are also phagocytes but are larger than neutrophils and tend to be found in organs such as the lungs, liver, spleen, kidney and lymph nodes, rather than remaining in the blood. After they are made in the bone marrow, macrophages travel in the blood as monocytes, which develop into macrophages once they leave the blood and settle in the organs, removing any foreign matter found there.

Macrophages are long-lived cells and play a crucial role in initiating immune responses, since they do not destroy pathogens completely, but cut them up to display antigens that can be recognised by lymphocytes.

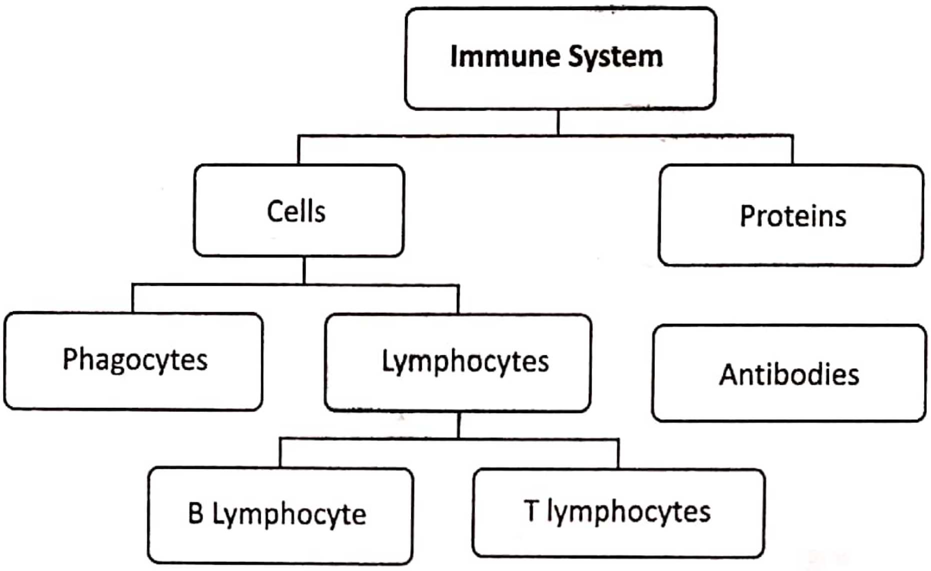
Lymphocytes

Lymphocytes are a second type of white blood cell. They play an important role in the immune response. Lymphocytes are smaller than phagocytes. They have a large nucleus that fills most of the cell. There are two types of lymphocyte, both of which are produced before birth in bone marrow.

- **B-lymphocytes** (B cells) remain in the bone marrow until they are mature and then spread throughout the body, concentrating in lymph nodes and the spleen.
- **T-lymphocytes** (T cells) leave the bone marrow and collect in the thymus where they mature. The thymus is a gland that lies in the chest just beneath the sternum. I doubles in size between birth and puberty, but after puberty it shrinks.

Only mature lymphocytes can carry out immune responses. During the maturation process, many different types of B- and T-lymphocyte develop, perhaps many millions. Each type is specialised to respond to one antigen, giving the immune system as a whole the ability to respond to almost any type of pathogen that enters the body.

Some of these activated B cells become plasma cells that produce antibody molecules very quickly – up to several thousand a second. Plasma cells secrete antibodies into the blood, lymph or onto the linings of the lungs and the gut. These plasma cells do not live long: after several weeks their numbers decrease. The antibody molecules they have secreted stay in the blood for longer, however, until they too eventually decrease in concentration.



T Lymphocytes are like the soldiers, destroying the invaders that the intelligence system has identified. T cells are also called killer cells.

Several types of cells work together to detect or recognize and respond antigens (foreign substances that invade the body). These cells trigger the B-lymphocytes to produce antibodies; specialized proteins that lock onto specific antigens.

The easiest way to get a better idea for the difference between antigen and antibody is to take a look at a close comparison of the two. They have different structures, functions, and locations within the body. One is generally considered a good thing to have as it protects your body while the other can provoke a negative reaction.

	Antigen	Antibody
Definition	An antigen is a foreign particle that can create an immune response within a person's body. They are also known by the term immunogenicity and can include pollen, viruses, bacteria, or chemicals.	Antibodies are also known as immunoglobulins and these proteins are created by the body. They work to fight against the antigens.
Chemical Components	Antigens are mostly made up of proteins, but they may also be nucleic acids, carbohydrates, or lipids.	Antibodies are proteins.
Different Types and	Antigens are typically divided into self and non-self-antigens. Self-antigens, like cancer	There are a total of 5 types of antibodies, each of which

Their Functions	cells, form within the body. Non-self-antigens come from outside the body. They stimulate your immune system to produce more antibodies, exemplifying the difference between antigen and antibody.	is different. They are Immunoglobulin A (IgA, also referred to as sIgA), IgE, IgG, IgM, and IgD.

IgA protects the surfaces of the body which receive exposure to foreign, outside substances. **IgE** causes a reaction in the body against foreign substances, including animal dander, pollen, and fungus spores. These antibodies are part of allergic reactions to some poisons and certain medications. Those with allergies tend to have high quantities of this type of antibody. **IgG** plays a key role in fighting infections of a bacterial or viral nature. These are the only antibodies that are able to cross the placenta of a pregnant woman, offering protection to the foetus while still in utero.

When an infection occurs, **IgM** antibodies are the very first type of antibodies to be made as a response. They will lead to other cells in the immune system destroying foreign substances. Experts are still unclear as to what exactly **IgD** antibodies do.

All healthy adults have thousands of various antibodies in small amounts throughout their body. Every antibody is very specialized, recognizing a single type of foreign substance. Most antibody molecules are shaped like a Y, featuring a binding site along each arm. Each binding site has a specific shape and only antigens with the same shape will fit in. Antibodies are designed to bond with the antigens. When binding, they make the antigens inactive, letting other processes in the body take over the foreign substances, removing and destroying them.

The first time a foreign substance enters the body, you may experience disease symptoms. This occurs when the immune system creates antibodies that will fight the foreign substance off. When the same antigen attacks again in the future, the attack stimulates immune memory. This leads to immediate large production of the antibody that was created the first time the attack occurred. The rapid response to further attacks means that you may not experience any disease symptoms or even know that you were exposed to the antigen. Some people may have also developed **immunity** to the foreign substance. This is why most people will only get diseases like chicken pox or measles once in their lives.

Immunity Types

Humans have three types of immunity — innate, adaptive and passive.

Innate Immunity: Everyone is born with innate (or natural) immunity, a type of general protection. Many of the germs that affect other species don't harm us. For example, the viruses that cause leukaemia in cats or distemper in dogs don't affect humans.

Adaptive Immunity / Vaccination: The second kind of protection is adaptive (or active) immunity, which develops throughout our lives. Adaptive immunity involves the lymphocytes and develops as people are exposed to diseases or immunized against diseases through vaccination.

Passive Immunity: Passive immunity is "borrowed" from another source and it lasts for a short time. For example, antibodies in a mother's breast milk provide a baby with temporary immunity to diseases the mother has been exposed to. This can help protect the baby against infection during the early years of childhood.

Everyone's immune system is different. Some people never seem to get infections, whereas others seem to be sick all the time. As people get older, they usually become immune to more germs as the immune system comes into contact with more and more of them. That's why, adults and teens tend to get fewer colds than kids — their bodies have learned to recognize and immediately attack many of the viruses that cause colds. Now let us discuss how to fight against diseases. There are two ways, one is to stop the disease from its attack, and however, if it has attacked the body then eliminate the cause of disease. Former refers to vaccination and later refers to antibiotics.

IMMUNIZATION OR VACCINATION

"A method of stimulating resistance in the human body to specific diseases-causing micro-organisms such as bacteria or viruses is called immunization or Vaccination." A **vaccine** is a biological preparation that improves immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing micro-organism, and is often made from weakened or killed forms of the microbe, its toxins or one of its surface proteins. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and "remember" it, so that the immune system can more easily recognize and destroy any of these micro-organisms that it later encounters.

Types of Vaccines

There are a few different types of vaccines. They include:

- **Attenuated (weakened)** live viruses are used in some vaccines such as in the measles, mumps, and rubella (MMR) vaccine.
- **Killed (inactivated)** viruses or bacteria are used in some vaccines, such as in Inactivated Polio Virus (IPV).
- **Toxoid vaccines** contain an inactivated toxin produced by the bacterium. For example, the diphtheria and tetanus vaccines are toxoid vaccines.
- **Conjugate vaccines** (such as Haemophilius Influeczae Type b or Hib) contain parts of bacteria combined with proteins.

Vaccine Side-effects

Some parents may hesitate to have their kids vaccinated because they're worried that the children will have serious reactions or may get the illness the vaccine is supposed to prevent. But because the components of vaccines are weakened or killed — and in some cases, only parts of the micro-organism are used — they're unlikely to cause any serious illness. Some vaccines may cause mild reactions, such as soreness where the shot was given or fever, but serious reactions are rare. The risks of vaccinations are small compared with the health risks associated with the diseases they're intended to prevent. Immunizations are one of the best means of protection against contagious diseases.

Effectiveness of Vaccines

Vaccines work really well. Of course, no medicine is perfect but most childhood vaccines produce immunity about 90 - 100% of the time. For most of the millions of people who get immunized every year, a protective effect occurs; however, in a small percentage of people, this is not the case. Ineffective immunization results when an individual's immune system does not respond appropriately. Vaccines can also be ineffective if not manufactured properly or not stored and handled properly.

How long does the effect of a vaccination last?

Some vaccinations last, but others do not. The protective effect weakens or wears off over time, or the organism that causes the disease may change (as the influenza virus often does), so that the inoculation generally needs to be given annually to protect against it. For some diseases, such as tetanus (lockjaw), the tendency for effectiveness to weaken over time can be overcome with follow-up immunizations. It is recommended that tetanus and diphtheria vaccines be given every 10 years to assure immunity to both tetanus and diphtheria.

Some Diseases and their Vaccines

Disease	Vaccine
Measles and mumps	MMR vaccine, MMRV vaccine
Anthrax	Anthrax vaccine
Whooping cough Tetanus Diphtheria	DPT
Tuberculosis	BCG vaccine
Poliomyelitis	Polio vaccine

- **DPT:** Diphtheria Purtosis and Tetanus
- **BCG:** Bacillus Calmette - Guérin
- **MMR:** Measles, Mumps and Rubella.
- **MMRV:** Measles, Mumps, Rubella and Varicella

ANTIBIOTICS

"Antibiotics (Greek anti, "against"; bios, "life") are chemical compounds used to kill or inhibit the growth of infectious organisms." Antibiotics are among the most frequently prescribed medications in modern medicine. The first antibiotic was penicillin, discovered from a mold culture. Today, over 100 different antibiotics are available to cure minor and life-threatening infections.

Although antibiotics are useful in a wide variety of infections, it is important to realize that antibiotics only treat *bacterial infections*. Antibiotics are useless against viral infections (for example, the common cold) and fungal infections (such as ringworm). Antibiotics can be provided in several ways:

- **oral antibiotics** – tablets, pills and capsules or a liquid that you drink, which can be used to treat most types of mild to moderate infections in the body.
- **topical antibiotics** – creams, lotions, sprays or drops, which are often used to treat skin infections.
- **injections of antibiotics** – these can be given as an injection or infusion through a drip directly into the blood or muscle, and are usually reserved for more serious infections.

Types of Antibiotics

There are now hundreds of different types of antibiotics, but most of them can be broadly classified into six groups. These are outlined below.

- **Penicillin** – widely used to treat a variety of infections, including skin infections, chest infections and urinary tract infections.
- **Cephalosporin** – can be used to treat a wide range of infections, but are also effective for treating more serious infections, such as septicaemia and meningitis.
- **Aminoglycosides** – tend to only be used to treat very serious illnesses such as septicaemia, as they can cause serious side-effects, including hearing loss and kidney damage; they break down quickly inside the digestive system, so they have to be given by injection, but are also used as drops for some ear or eye infections.
- **Tetracycline** – can be used to treat a wide range of infections; commonly used to treat moderate to severe acne and rosacea, which causes flushing of the skin and spots.
- **Macrolides** – can be particularly useful for treating lung and chest infections; can also be a useful alternative for people with a penicillin allergy or to treat penicillin-resistant strains of bacteria.
- **Fluoroquinolones** – broad-spectrum antibiotics that can be used to treat a wide range of infections.

Side-effects of Antibiotics

The most common side-effects of antibiotics is that these affect the digestive system. Side-effects of antibiotics include:

- being sick
- feeling sick
- diarrhoea
- bloating and indigestion
- abdominal pain
- loss of appetite

These side-effects are usually mild and should pass once you finish your course of treatment. Around one person in 15 has an allergic reaction to antibiotics, especially penicillin and cephalosporin. In very rare cases, this can lead to a serious allergic reaction.

How do Antibiotics Work?

Antibiotics work in one of two ways:

- they kill bacteria by disrupting one of the processes they need to survive, such as turning glucose into energy
- they prevent bacteria reproducing and spreading – for example, by disrupting the processes bacteria use to produce new cells, such as growing new proteins

Antibiotic Resistance

When a strain of bacteria no longer responds to treatment with one or more types of antibiotics it is said to be antibiotic resistant. Antibiotic resistance can occur in several ways. Strains of bacteria can change (mutate) and, over time, become resistant to a specific antibiotic.

The chance of this increases if a person does not finish the course of antibiotics they have been prescribed, as some bacteria may be left to develop resistance. Antibiotics can also destroy many of the harmless strains of bacteria that live in and on the body. This allows resistant bacteria to multiply quickly and replace them.

The overuse of antibiotics in recent years has played a major part in antibiotic resistance. This includes using antibiotics to treat minor conditions that would have got better anyway. It has led to the emergence of "superbugs". These are strains of bacteria that have developed resistance to many different types of antibiotics. These types of infections can be serious and challenging to treat, and are becoming an increasing cause of disability and death across the world. The biggest worry is new strains of bacteria may emerge that cannot be effectively treated by any existing antibiotics.

Inappropriate use and prescribing of antibiotics is causing the development of resistance. Inappropriate use includes:

- not taking antibiotics as prescribed
- skipping doses of antibiotics
- not taking antibiotics at regular intervals
- saving some for later usage.

Inappropriate prescribing includes:

- unnecessary prescription of antibiotics
- unsuitable use of broad-spectrum antibiotics
- wrong selection of antibiotics and inappropriate duration or dose of antibiotics

To help prevent antibiotic resistance

- Don't use antibiotics for viruses like colds or flu. Antibiotics don't work on viruses.
- Don't pressure your doctor to give you an antibiotic.
- When you take antibiotics, follow the directions carefully. Finish your medicine even if you feel better. If you stop treatment too soon, some bacteria may survive and re-infect you.
- Don't save antibiotics for later or use someone else's prescription.

POLIO

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children. Polio cases have decreased by over 99% since 1988, from an estimated 350 000 cases then, to 74 reported cases in 2015. The reduction is the result of the global effort to eradicate the disease. There are just 2 countries which have never stopped transmission of polio. The 2 countries are Afghanistan and Pakistan. They face a range of challenges such as insecurity, weak health systems and poor sanitation. Polio can spread from these 'endemic' countries to infect children in other countries with less-than-adequate vaccination.

Unlike most diseases, polio can be completely eradicated. There are 3 strains of wild poliovirus, none of which can survive for long periods outside of the human body. If the virus cannot find an unvaccinated person to infect, it will die out. Type 2 wild poliovirus was eradicated in 1999 and case numbers of type 3 wild poliovirus are down to the lowest-ever levels.

As long as a single child remains infected, children in all countries are at risk of contracting polio. Failure to eradicate polio from these last remaining strongholds could result in as many as 200, 000 new cases every year, within 10 years, all over the world.

Symptoms

Polio is a highly infectious disease caused by a virus. It invades the nervous system, and can cause total paralysis in a matter of hours. Initial symptoms are fever, fatigue, headache, vomiting, and stiffness in the neck and pain in the limbs. One in 200 infections leads to irreversible paralysis (usually in the legs). Among those paralysed, 5% to 10% die when their breathing muscles become immobilized. Polio mainly affects children under 5 years of age.

How polio spreads and develops

The poliovirus spreads in human faeces. People become infected with the virus through contaminated food and water, especially in areas where sanitation and hygiene are poor. Improper sewage disposal, for example, can contaminate a water supply. Poliovirus typically enters the body through the mouth and proceeds through the digestive tract to the intestines. After multiplying in the body, the virus is shed in the faeces, from which it can spread and cause further infections, especially when infected people do not wash their hands and touch food or other people. Adults can become infected by changing the diapers of an infected infant and then touching their mouth.

Prevention

There is no cure for polio, it can only be prevented. Immunization with polio vaccine is the best way to prevent polio. Vaccines work by exposing the body's immune system to a microbial infection that is strong enough to provoke an immune response but not severe enough to result in full-blown illness. In response to the infection, the immune system produces antibodies to fight the infectious agent. Once the body has overcome the challenge of the vaccine-induced infection, the antibodies can recognize and quickly handle any subsequent invasion by the same agent.

Polio Vaccine

There are two types of vaccine that protect against polio: Inactivated Polio Vaccine (IPV) and Oral Polio Vaccine (OPV). IPV is given as an injection in the leg or arm, depending on age. OPV is taken by mouth. Polio vaccine may be given at the same time as other vaccines. Most people should get polio vaccine when they are children. Children should be vaccinated with four doses of inactivated polio vaccine (IPV) at the following ages:

- A dose at 2 months
- A dose at 4 months
- A dose at 6-18 months
- A booster dose at 4-6 years

Most adults do not need polio vaccine because they were already vaccinated as children.

DIARRHOEA

Diarrhoea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not diarrhoea, nor is the passing of loose, "pasty" stools by breastfed babies. Diarrhoea is usually a symptom of an infection in the intestinal tract, which can be caused by a variety of bacterial, viral and parasitic organisms. Infection is spread through contaminated food or drinking-water, or from person-to-person as a result of poor hygiene. There are three clinical types of diarrhoea:

- acute watery diarrhoea – lasts several hours or days, and includes cholera;
- acute bloody diarrhoea – also called dysentery; and
- persistent diarrhoea – lasts 14 days or longer.

Scope of diarrhoeal disease

Diarrhoeal disease is a leading cause of child mortality and morbidity in the world, and mostly results from contaminated food and water sources. Worldwide, 780 million individuals lack access to improved drinking-water and 2.5 billion lack improved sanitation. Diarrhoea due to infection is widespread throughout developing countries. In developing countries, children under three years old experience on average three episodes of diarrhoea every year. Each episode deprives the child of the nutrition necessary for growth. As a result, diarrhoea is a major cause of malnutrition, and malnourished children are more likely to fall ill from diarrhoea.

The most severe threat posed by diarrhoea is dehydration. During a diarrhoeal episode, water and electrolytes (sodium, chloride, potassium and bicarbonate) are lost through liquid stools, vomit, sweat, urine and breathing. Dehydration occurs when these losses are not replaced. Death can follow severe dehydration if body fluids and electrolytes are not replenished, either through the use of oral rehydration salts (ORS) solution, or through an intravenous drip.

Causes

Infection: Diarrhoea is a symptom of infections caused by a host of bacterial, viral and parasitic organisms, most of which are spread by faeces-contaminated water. Infection is more common when there is a shortage of adequate sanitation and hygiene and safe water for drinking, cooking and cleaning. Viral diarhoea is caused by *rotavirus* and *norovirus*, while bacterial diarhoea is caused by *clostridium* and *campylobacter*.

Malnutrition: Children who die from diarrhoea often suffer from underlying malnutrition, which makes them more vulnerable to diarrhoea. Each diarrhoeal episode, in turn, makes their malnutrition even worse. Diarrhoea is a leading cause of malnutrition in children under five years old.

Source: Water contaminated with human faeces, for example, from sewage, septic tanks and latrines, is of particular concern. Animal faeces also contain microorganisms that can cause diarrhoea. Diarrhoeal disease can also spread from person-to-person, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation. Fish and seafood from polluted water may also contribute to the disease.

Prevention and treatment

Key measures to prevent diarrhoea include:

- access to safe drinking-water;
- use of improved sanitation;
- hand washing with soap;
- exclusive breastfeeding for the first six months of life;

- good personal and food hygiene;
- health education about how infections spread; and
- rotavirus vaccination.

Key measures to treat diarrhoea include the following:

- **Rehydration:** with oral rehydration salts (ORS) solution. ORS is a mixture of clean water, salt and sugar. ORS is absorbed in the small intestine and replaces the water and electrolytes lost in the faeces.
- **Zinc supplements:** zinc supplements reduce the duration of a diarrhoea episode by 25% and are associated with a 30% reduction in stool volume.
- **Nutrient-rich foods:** the vicious circle of malnutrition and diarrhoea can be broken by continuing to give nutrient-rich foods – including breast milk – during an episode, and by giving a nutritious diet to children when they are well.
- **Consulting a health professional:** in particular for management of persistent diarrhoea or when there is blood in stool or if there are signs of dehydration.

MALARIA

Malaria is caused by Plasmodium parasites. The parasite spread to people through the bites of infected female *Anopheles* mosquitoes, called "malaria vectors." There are 5 parasite species that cause malaria in humans, and 2 of these species –*P. falciparum* and *P. vivax* – pose the greatest threat. *P. falciparum* is the most prevalent malaria parasite on the African continent. It is responsible for most malaria-related deaths globally. *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa.

According to the latest WHO estimates, released in December 2015, there were 214 million cases of malaria in 2015 and 438 000 deaths. In areas with high transmission of malaria, children under 5 are particularly susceptible to infection, illness and death; more than two thirds (70%) of all malaria deaths occur in this age group.

Symptoms of Malaria

Malaria is an acute feverish illness. In a non-immune individual, symptoms appear 7 days or more (usually 10–15 days) after the infective mosquito bite. The first symptoms – fever, headache, chills and vomiting – may be mild and difficult to recognize as malaria. If not treated within 24 hours, *P. falciparum* malaria can progress to severe illness, often leading to death.

Children with severe malaria frequently develop one or more of the following symptoms: severe anaemia, respiratory distress in relation to metabolic acidosis, or cerebral malaria. In adults, multi-organ involvement is also frequent. In malaria endemic areas, people may develop partial immunity, allowing asymptomatic infections to occur.

Transmission of malaria

Female *Anopheles* mosquitoes feed on human blood to obtain the protein they need to develop their eggs. If the person they bite is infected with *Plasmodium*, they will take up some of the pathogen's gametes with the blood meal. Male and female gametes fuse in the mosquito's gut and develop to form infective stages, which move to the mosquito's salivary glands. When the mosquito feeds again, she injects an anticoagulant from her salivary glands that prevents the blood meal from clotting, so that it flows out of the host into the mosquito. The infective stages pass from the mosquito's salivary glands into the human's blood together with the anticoagulant in the saliva. The parasites enter the red blood cells, where they multiply. The female *Anopheles* mosquito is therefore a vector of malaria and she transmits the disease when she passes the infective stages into an uninfected person.

Preventing Malaria

Vector control is the main way to prevent and reduce malaria transmission. If coverage of vector control interventions within a specific area is high enough, then a measure of protection will be conferred across the community. WHO recommends protection for all people at risk of malaria with effective malaria vector control. Two forms of vector control – insecticide-treated mosquito nets and indoor residual spraying – are effective in a wide range of circumstances.

Antimalarial medicines can also be used to prevent malaria. For travellers, malaria can be prevented through chemoprophylaxis, which suppresses the blood stage of malaria infections, thereby preventing malaria disease.

Treating Malaria

Early diagnosis and treatment of malaria reduces disease and prevents deaths. It also contributes to reducing malaria transmission. The best available treatment, particularly for *P. falciparum* malaria, is artemisinin-based combination therapy (ACT).

If malaria is diagnosed and treated promptly, virtually everyone will make a full recovery. Treatment should be started as soon as the diagnosis has been confirmed. Anti-malarial medication is used both to treat and prevent malaria. Malaria is a serious illness that can get worse very quickly and can be fatal if not treated promptly. There are currently no licensed vaccines against malaria or any other human parasite.

HEPATITIS

Hepatitis refers to an inflammatory condition of the liver. It's commonly caused by a viral infection, but there are other possible causes of hepatitis. These include autoimmune hepatitis and hepatitis that occurs as a secondary result of medications, drugs, toxins, and alcohol. Autoimmune hepatitis is a disease that occurs when body makes antibodies against liver tissue. Initial **symptoms** of hepatitis caused by infection are similar to the flu and include:

- muscle and joint pain,
- a high temperature (fever) of 38°C (100.4°F) or above,
- feeling sick,
- being sick,
- headache and
- occasionally, yellowing of the eyes and skin (jaundice).

Symptoms of chronic hepatitis can include:

- feeling unusually tired all the time
- depression,
- jaundice and
- a general sense of feeling unwell

In many cases hepatitis causes no noticeable symptoms, so when hepatitis is caused by a virus, many people are unaware they are infected. Around the world 400 million people are infected with hepatitis B and C, more than 10 times the number of people living with HIV. An estimated 1.45 million people died of the disease in 2013 – up from less than a million in 1990 (WHO). Today, only 1 in 20 people with viral hepatitis know they have it. And just 1 in 100 with the disease is being treated. Viral infections of the liver that are classified as hepatitis include hepatitis A, B, C, D, and E. Hepatitis A is a milder version of the disease, and hepatitis C and D are more severe.

Hepatitis A

- Hepatitis A is a viral liver disease that can cause mild to severe illness.
- The hepatitis A virus (HAV) is transmitted through ingestion of contaminated food and water or through direct contact with an infectious person.
- Almost everyone recovers fully from hepatitis A with a lifelong immunity. However, a very small proportion of people infected with hepatitis A could die from fulminant hepatitis (acute liver failure).
- The risk of hepatitis A infection is associated with a lack of safe water, and poor sanitation and hygiene (such as dirty hands).
- Epidemics can be explosive and cause substantial human and economic loss.
- A safe and effective vaccine is available to prevent hepatitis A.
- Safe water supply, food safety, improved sanitation, hand washing and the hepatitis A vaccine are the most effective ways to combat the disease.

Hepatitis B

- Hepatitis B is a viral infection that attacks the liver and can cause both acute and chronic disease.
- The virus is transmitted through contact with the blood or other body fluids of an infected person.
- An estimated 240 million people are chronically infected with hepatitis B (defined as hepatitis B surface antigen positive for at least 6 months).
- More than 686000 people die every year due to complications of hepatitis B, including cirrhosis and liver cancer.
- Hepatitis B is an important occupational hazard for health workers.
- However, it can be prevented by currently available safe and effective vaccine.

Hepatitis C

- Hepatitis C is a liver disease caused by the hepatitis C virus: the virus can cause both acute and chronic hepatitis infection, ranging in severity from a mild illness lasting a few weeks to a serious, lifelong illness.
- The hepatitis C virus is a blood borne virus and the most common modes of infection are through unsafe injection practices, inadequate sterilization of medical equipment and the transfusion of unscreened blood and blood products.
- Globally, between 130–150 million people have chronic hepatitis C infection.

- A significant number of those who are chronically infected will develop liver cirrhosis or liver cancer.
- Approximately 700000 people die each year from hepatitis C-related liver diseases.
- Antiviral medicines can cure approximately 90% of persons with hepatitis C infection, thereby reducing the risk of death from liver cancer and cirrhosis, but access to diagnosis and treatment is low.
- There is currently no vaccine for hepatitis C; however research in this area is ongoing.

Hepatitis Diagnosis

Liver Biopsy: A liver biopsy is an invasive procedure that involves the doctor taking a sample of tissue from your liver. This is a closed procedure. In other words, it can be done through the skin with a needle and doesn't require surgery. This test allows doctor to determine if an infection or inflammation is present or if liver damage has occurred.

Liver Function Tests: Liver function tests use blood samples to determine how efficiently the liver works. These tests check how the liver clears blood waste, protein, and enzymes. High liver enzyme levels may indicate that the liver is stressed or damaged.

Ultrasound: An abdominal ultrasound uses ultrasound waves to create an image of the organs within the abdomen. This test will reveal fluid in the abdomen, an enlarged liver, or liver damage.

Blood Tests: Blood tests used to detect the presence of hepatitis virus antibodies and antigen in the blood will indicate or confirm which virus is the cause of the hepatitis.

Viral Antibody Testing: Further viral antibody testing may be needed to determine if a specific type of the hepatitis virus is present.

Treatment

Treatment options are determined by which type of hepatitis you have and whether the infection is acute or chronic.

Hepatitis A

Hepatitis A isn't usually treated. Bed rest may be recommended if symptoms cause a great deal of discomfort. If you experience vomiting or diarrhea, you will be put on a special diet created by your doctor to prevent malnutrition or dehydration. Vaccination can also prevent hepatitis A infections by helping your body produce the antibodies that fight this type of infection. Most children receive the vaccination between ages 12 and 18 months. Vaccination is also available for adults.

Hepatitis B

Acute hepatitis B doesn't require specific treatment. Chronic hepatitis B is treated with antiviral medications. This form of treatment can be costly because it must be followed for several months or years. Treatment for chronic hepatitis B also requires regular medical evaluations and monitoring to determine if the virus is progressing.

Hepatitis C

Antiviral medications are used to treat both acute and chronic forms of hepatitis C. People who develop chronic hepatitis C are typically treated with a combination of antiviral drug therapies. They may also need further testing to determine the best form of treatment. People who develop cirrhosis (scarring of the liver) or liver disease as a result of chronic hepatitis C may be candidates for a liver transplant.

Preventing Hepatitis

Hepatitis B and C infections are transmitted through contaminated blood as well as through contaminated needles and syringes in healthcare setting and among people who inject drugs. The viruses can also be transmitted through unsafe sex and from an infected mother to her newborn child. As of 2014, 184 countries vaccinate infants against hepatitis B as part of their vaccination schedules and 82% of children in these states received the hepatitis B vaccine. This is a major increase compared with 31 countries in 1992, the year that the World Health Assembly passed a resolution to recommend global vaccination against hepatitis B.

In addition, implementing blood safety strategies, including quality-assured screening of all donated blood and blood components used for transfusion, can help prevent transmission of hepatitis B and C. Safe injection practices, eliminating unnecessary and unsafe injections, can be effective strategies to protect against transmission. Safer sex practices, including minimizing the number of partners and using barrier protective measures, also protect against transmission.

DENGUE

Dengue is a mosquito-borne viral disease that has rapidly spread in all regions in recent years. Dengue virus is transmitted by female mosquitoes mainly of the species *Aedes aegypti* and, to a lesser extent, *Ae. albopictus*. This mosquito also transmits chikungunya, yellow fever and Zika infection. Dengue is widespread throughout the tropics, with local variations in risk influenced by rainfall, temperature and unplanned rapid urbanization.

Severe dengue (also known as Dengue Haemorrhagic Fever) was first recognized in the 1950s during dengue epidemics in the Philippines and Thailand. Today, severe dengue affects most Asian and Latin American countries and has become a leading cause of hospitalization and death among children and adults in these regions.

There are 4 distinct, but closely related, serotypes of the virus that cause dengue (DEN-1, DEN-2, DEN-3 and DEN-4). Recovery from infection by one provides lifelong immunity against that particular serotype. However, cross-immunity to the other serotypes after recovery is only partial and temporary. Subsequent infections by other serotypes increase the risk of developing severe dengue.

Symptoms

Dengue fever is a severe, flu-like illness that affects infants, young children and adults, but seldom causes death. Dengue should be suspected when a high fever (40°C/104°F) is accompanied by 2 of the following symptoms: severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, swollen glands or rash. Symptoms usually last for 2–7 days, after an incubation period of 4–10 days after the bite from an infected mosquito.

Severe dengue is a potentially deadly complication due to plasma leaking, fluid accumulation, respiratory distress, severe bleeding, or organ impairment. Warning signs occur 3–7 days after the first symptoms in conjunction with a decrease in temperature (below 38°C/100°F) and include: severe abdominal pain, persistent vomiting, rapid breathing, bleeding gums, fatigue, restlessness and blood in vomit. The next 24–48 hours of the critical stage can be lethal; proper medical care is needed to avoid complications and risk of death.

Transmission

The *Aedes aegypti* mosquito is the primary vector of dengue. The virus is transmitted to humans through the bites of infected female mosquitoes. After virus incubation for 4–10 days, an infected mosquito is capable of transmitting the virus for the rest of its life.

Infected symptomatic or asymptomatic humans are the main carriers and multipliers of the virus, serving as a source of the virus for uninfected mosquitoes. Patients who are already infected with the dengue virus can transmit the infection (for 4–5 days; maximum 12) via *Aedes* mosquitoes after their first symptoms appear.

The *Aedes aegypti* mosquito lives in urban habitats and breeds mostly in man-made containers. Unlike other mosquitoes *Aedes aegypti* is a day-time feeder; its peak biting periods are early in the morning and in the evening before dusk. Female *Aedes Aegypti* bites multiple people during each feeding period. There is no specific treatment for dengue fever. For severe dengue, medical care by physicians and nurses experienced with the effects and progression of the disease can save lives.

Immunization

In late 2015 and early 2016, the first dengue vaccine, Dengvaxia (CYD-TDV) by Sanofi Pasteur, was registered in several countries for use in individuals 9-45 years of age living in endemic areas.

Prevention and Control

At present, the main method to control or prevent the transmission of dengue virus is to combat vector mosquitoes through:

- preventing mosquitoes from accessing egg-laying habitats by environmental management and modification;
- disposing of solid waste properly and removing artificial man-made habitats;
- covering, emptying and cleaning of domestic water storage containers on a weekly basis;
- applying appropriate insecticides to water storage outdoor containers;
- using of personal household protection such as window screens, long-sleeved clothes, insecticide treated materials, coils and vaporizers;
- improving community participation and mobilization for sustained vector control;
- applying insecticides as space spraying during outbreaks as one of the emergency vector-control measures and
- active monitoring and surveillance of vectors should be carried out to determine effectiveness of control interventions.